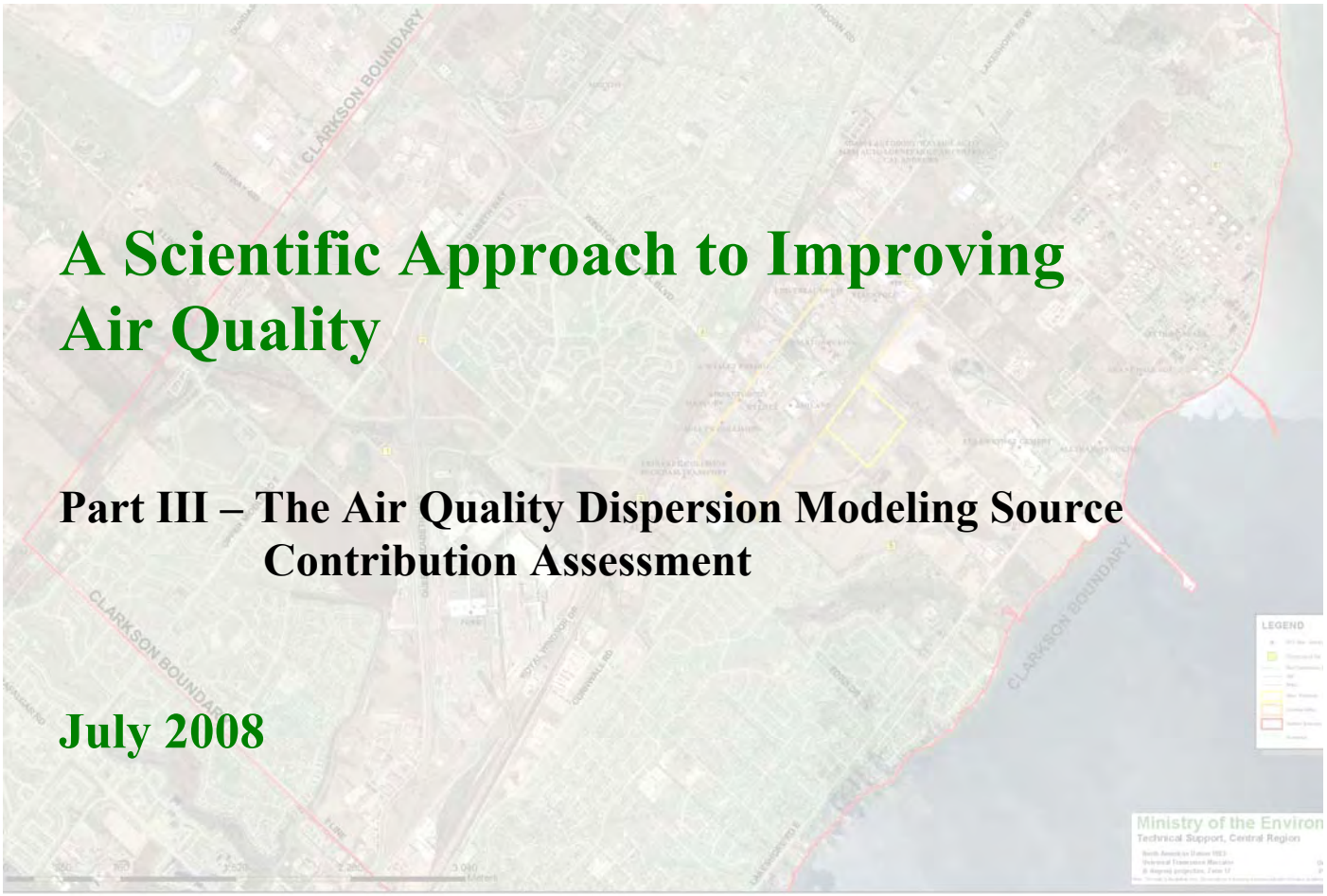
CLARKSON AIRSHED STUDY



A Scientific Approach to Improving Air Quality

Part III – The Air Quality Dispersion Modeling Source Contribution Assessment

July 2008

MINISTRY OF THE ENVIRONMENT

CENTRAL REGION

Protecting our environment. Ontario

ACKNOWLEDGEMENTS

This report has been prepared with contribution from the Ontario Ministry of the Environment's Central Region, Technical Support Section, and Halton-Peel District Office, and from the Environmental Monitoring and Reporting Branch. Environment Canada is also acknowledged for providing air toxics data and analysis to this study.

Executive Summary

Clarkson Airshed Study:
Part III – The Air Quality Dispersion Modeling Source Contribution Assessment

In December of 2006, the Ministry of the Environment (Ministry) initiated Part III of the Clarkson Airshed Study entitled "The Air Quality Dispersion Modeling Source Contribution Assessment".

The primary objective of this assessment was to use the monitoring data developed in the document entitled "Clarkson Airshed Study, A Scientific Approach to Improving Air Quality, Part II - The Ambient Air Monitoring Program" (Ministry report dated Nov 2006) and the CALMET/CALPUFF air dispersion modelling system, to determine the relative contributions of various air emission sources to the total contaminant concentrations measured at the six Part II Ministry air monitoring stations.

More so than any other part of the Clarkson Airshed Study, the conclusions reached during this part of the Study were particularly tied to the approach taken in completing the work. As such, it is important to include discussion of the components of this approach as a significant "Conclusion" in this report on the Part III assessment.

The key components of the Part III assessment used in the approach to developing the source contribution data base were:

(i) The definition of 4 source sectors – (a) Industrial (process stack emissions, process and vehicle/road dust fugitive emissions); (b) Vehicular (tailpipe and surface re-suspended road dust emissions from travel on public roadways); (c) Residential (heating) and; (d) Miscellaneous (a general category which may include such sources as: dry cleaning, fuel marketing, general solvent use, pesticides and fertilizer applications etc).

(ii) The selection of 10 individual industry sources located in the Clarkson Airshed study area which were considered as important contributors to sector emissions.

(iii) The identification of key contaminants of interest, namely: (a) particulate matter less than or equal to 10 microns in size (PM_{10}), (b) particulate matter less than or equal to 2.5 microns in size ($PM_{2.5}$), (c) nitrogen oxides (NO_x) and, (d) total volatile organic compounds (VOCs).

(iv) The development of a comprehensive inventory of all significant air emission sources located both within, and in the vicinity of, the Clarkson Airshed study area.

(v) The use of the CALMENT/CALPUFF dispersion modelling system (version 5.711a) to develop predicted contaminant concentrations and help define the contributions of the various source sectors to air quality in the airshed study area.

The entire Part III assessment focused on the use of measured 2004 data collected during the Part II Ambient Air Monitoring Program and dealt with annual average and 98^{th} percentile, 24 hour contaminant concentrations. The year 2004 is the only complete year for which Part II monitoring data were available.

For the four source sectors evaluated in the Part III assessment, the most significant contributor to contaminant concentrations measured at the Ministry monitoring stations was the Vehicular sector. This was true for PM_{10}, $PM_{2.5}$ and NOx emissions, accounting for about 50-70% of the total measured contaminant values. In this regard, the Industrial Sector was somewhat of a distant second and accounted for only 25-35% of the total measured values. The Miscellaneous source sector dominated the measured VOC contaminant concentrations accounting for about 40% of the total measured values.

Since the impacts from vehicular traffic related to particulate matter and nitrous oxides were so significant, further study and analysis is required in order to address potential mitigation approaches for this source sector and to validate the uncertainties in the fugitive emission data (postal code CAC database) used in the Part III assessment.

Of the total contaminant concentrations, long-range or transboundary sources and sources outside of the Clarkson Airshed study area accounted for about 15-60% of the measured values. For example, at least on occasion, in the order of 50% or more of the measured $PM_{2.5}$ was attributed to long-range transport from the USA.

The two most significant air emission sources on either side of the Clarkson Airshed study area are: the Lakeview Generating Station and the Petro Canada Oakville refinery. These two sources have been often suggested as being significant factors impacting air quality within the study area. However, the results of the Part III assessment do not support this suggestion and in

fact <.1 to 6% of all contaminant concentrations measured in the study area were attributed to these sources.

One of the most important data sets developed in Part III of the Clarkson Airshed Study were the "Industrial Source Contribution Matrices". These matrices provide predicted and measured data on 10 selected Clarkson Airshed study area industries. They were prepared in such a way that they can be effectively used for screening the effect of changes to emissions attributed to individual industries from the standpoint of process optimization and continuing efforts to reduce emissions.

Of the 10 individual industries assessed, the key contributors to the contaminant concentrations measured at the six Ministry Clarkson air monitoring stations were: St. Lawrence Cement, Petro Canada, Ford, Universal Drum and, Stackpole.

A key indicator of the effectiveness of the Part III assessment was the demonstrated accuracy of the CALMET/CALPUFF modelling system. A statistical analysis using Q-Q plots and a fractional bias approach both yielded values within a factor of two (2) which demonstrated that, on the average, the predicted values determined by the model did provide reasonable agreement with measured values.

Part IV of the Clarkson Airshed Study began in the spring of 2007 with the formation of the Clarkson Airshed Advisory Committee (CASAC). The Committee, which was convened by the Halton Peel District Office of the Ministry, is a multi-stakeholder partnership which meets every 2 months. Eleven industries are represented on the CASAC which also includes representatives from: (i) the local community; (ii) the local Health Units; (iii) municipalities and; (iv) local politicians.

The mandate of the Advisory Committee is to set-up and operate an air quality management system within the Clarkson area on the basis of shared responsibility and the utilization of a consensus building, collaborative approach toward improving air quality. The Committee is presently working with an environmental consultant on the development and implementation of a permanent ambient air monitoring program for the Clarkson Airshed study area and vicinity.

It is also expected that towards the end of 2008 and into early 2009, participating industries will begin designing and implementing abatement programs to focus on further reductions in air emissions of the targeted pollutants. The source contribution matrices which were developed in the Part III Clarkson Airshed Study should prove very useful in tracking the success of these reductions.

In order to achieve better air quality in the Clarkson area, the original focus of the CASAC has been to get commitments from industry to “go beyond compliance”. This approach, which has been adopted in other cities such as Hamilton, will be successful if it has the cooperation of industry, commercial businesses and other levels of government.

Table of Contents

Clarkson Airshed Study:
Part III – The Air Quality Dispersion Modeling Source Contribution Assessment

CONTENTS **PAGE**

LIST OF TABLES

LIST OF FIGURES

SECTION - ONE Glossary of Terms…… 1-1

SECTION - TWO Purpose of the Study and Outline of Basic Approach……. 2-1
2.0 Introduction…….2-1
2.1 Study Area…….. 2-2
2.2 Method of Assessment……2-2
2.2.1 The Select Contaminants……..2-3
2.2.2 Air Emissions Inventory……...2-4
2.2.3 Air Dispersion/Meteorological Modeling…..……2-4
2.2.4 Source Sector Measured Concentrations and Industry Source Contribution Matrices……2-5

SECTION - THREE Inventory of Contaminant Emissions……....…….…… 3-1
3.0 Introduction…….3-1
3.1 Emissions – Industry Point Sources/Stacks…… 3-2
3.2 Emissions – Industry "Fugitive"…….3-3
3.3 Emissions - Vehicular (Public Roadways)…… 3-3
3.4 Emissions - Residential……...3-4
3.5 Emissions - Miscellaneous…… 3-4
3.6 Results – Total Source Sector Emission Data…….3-4

SECTION - FOUR Air Dispersion Modeling Methodology……....…… 4-1
4.0 Introduction-Model Selection…….4-1
4.1 Meso-Scale Meteorology……4-1
4.2 Calmet Meteorological Model…….4-2
4.2.1 Wind Field Layer Heights…….4-3
4.2.2 Terrain Data……..4-3
4.2.3 Land Use Data……..4-3
4.2.4 Performance of Meteorological Models…….. 4-4
4.3 CALMET/CALPUFF Modeling System……4-4
4.3.1 Modeling Domains and Receptor Grids…….. 4-4

Table of Contents

CONTENTS **PAGE**

4.3.2 Modeled Source Locations……4-5
4.3.3 Discrete Receptors – Ministry Monitoring Locations…….. ……4-5

SECTION - FIVE Assessment Results - Clarkson Airshed Study Area 5-1
5.0 Introduction……5-1
5.1 Source Sector Contaminant Concentrations……5-2
5.1.1 Particulate Matter Less Than or Equal to 10 Microns (PM_{10})…… 5-3
5.1.2 Particulate Matter Less Than or Equal to 2.5 Microns ($PM_{2.5}$)……...5-4
5.1.3 Nitrogen Oxides (NO_x)……5-6
5.1.4 Volatile Organic Compounds (VOCs)…… 5-8
5.1.5 Influence of Emissions from Lakeview Generating Station and Petro-Canada Oakville Refinery……5-10
5.2 Industry Source Contribution Matrix…… 5-11
5.2.1 Particulate Matter Less Than or Equal to 10 Microns (PM_{10})…… 5-13
5.2.2 Particulate Matter Less Than or Equal to 2.5 Microns($PM_{2.5}$)……..5-15
5.2.3 Nitrogen Oxides (NO_x)……5-16
5.2.4 Volatile Organic Compounds (VOCs)……5-18
5.3 Evaluation of CALPUFF Model Performance……5-20
5.3.1 Bias Plots……5-20
5.3.2 Q-Q Plots……5-21

SECTION - SIX Assessment Results - Transport of Air Contaminants Into the Clarkson Airshed Study Area…… ……..... 6-1
6.0 Introduction……6-1
6.1 Contributions From "Locally Derived" Sources…… 6-1
6.2 Contributions From Outside of the Clarkson Airshed Study Area…… 6-3

SECTION - SEVEN Conclusions and Next Steps..... 7-1
7.0 Conclusions……..7-1
7.1 Next Steps……7-5

SECTION - EIGHT References..... 8-1

APPENDIX A Stack Parameters

List of Tables

Clarkson Airshed Study:
Part III – The Air Quality Dispersion Modeling Source Contribution Assessment

NUMBER AND TITLE OF TABLE **PAGE**

TABLE 3.1 Summary of Source Sector Emissions - 2004 (Tonnes/Year) ..... ……..3-5

TABLE 3.2 Summary of Total Emissions from Selected Industrial Facilities – 2004 (Tonnes/Year)..... 3-6

TABLE 4.1 CALMET Wind Field Layer Heights 4-3

TABLE 4.2 Summary of Receptor/Monitoring Station Names and Coordinates 4-5

TABLE 5.1(a) PM_{10} - Predicted Average Concentrations By Source Sector ($\mu g/m^3$)……...…….5-3

TABLE 5.1(b) PM_{10} - Measured Concentrations By Source Sector ($\mu g/m^3$)..……....……5-3

TABLE 5.1(c) PM_{10} - Percent Contributions By Source Sector..... 5-4

TABLE 5.2(a) $PM_{2.5}$ - Predicted Average Concentrations By Source Sector ($\mu g/m^3$)..... 5-5

TABLE 5.2(b) $PM_{2.5}$ - Measured Concentrations By Source Sector ($\mu g/m^3$)..... 5-6

TABLE 5.2(c) $PM_{2.5}$ - Percent Contribution By Source Sector..... 5-6

TABLE 5.3(a) NO_x - Predicted Average Concentrations By Source Sector ($\mu g/m^3$)..... 5-6

TABLE 5.3(b) NO_x - Measured Concentrations By Source Sector ($\mu g/m^3$)..... 5-7

TABLE 5.3(c) NO_x - Percent Contribution By Source Sector..... 5-7

List of Tables

NUMBER AND TITLE OF TABLE **PAGE**

TABLE 5.4(a) VOC - Predicted Average Concentrations By Source Sector (µg/m^3) 5-8

TABLE 5.4(b) VOC - Measured Concentrations By Source Sector (µg/m^3) 5-9

TABLE 5.4(c) VOC - Percent Contribution By Source Sector 5-9

TABLE 5.5 Emission Summary for Lakeview Generating Station & Petro-Canada Oakville Refinery (2004) 5-10

TABLE 5.6 Predicted Annual Average Contaminant Concentrations at Ministry Monitoring Stations - From Lakeview Generating Station (µg/m^3) 5-11

TABLE 5.7 Predicted Annual Average Contaminant Concentrations at Ministry Monitoring Stations- From Petro-Canada, Oakville (µg/m^3)..... 5-11

TABLE 5.8(a) Industry Source Contribution Matrix – PM_{10} Predicted Average Concentrations (µg/m^3) 5-13

TABLE 5.8(b) Industry Source Contribution Matrix – PM_{10} Measured 98th Percentile Concentrations (µg/m^3)…… ……. 5-14

TABLE 5.9(a) Industry Source Contribution Matrix – $PM_{2.5}$ Predicted Average Concentrations (µg/m^3)..... 5-15

TABLE 5.9(b) Industry Source Contribution Matrix – $PM_{2.5}$ Measured 98th Percentile Concentrations (µg/m^3)..... 5-16

TABLE 5.10(a) Industry Source Contribution Matrix – NO_x Predicted Average Concentrations (µg/m^3)..... 5-17

TABLE 5.10(b) Industry Source Contribution Matrix – NO_x Measured 98th Percentile Concentrations (µg/m^3)..... 5-18

TABLE 5.11(a) Industry Source Contribution Matrix – VOC Predicted Average Concentrations (µg/m^3)..... 5-19

List of Tables

NUMBER AND TITLE OF TABLE **PAGE**

TABLE 5.11(b) Industry Source Contribution Matrix –VOC Measured 98th Percentile Concentrations (µg/m3)..... 5-20

TABLE 6.1 Predicted SO_4 and NO_3 Concentrations at Ministry Monitoring Stations 6-2

TABLE 6-2 Contaminant Concentrations in Clarkson Airshed Study Area Resulting From Sources Outside of the Study Area (µg/m3)..... 6-3

TABLE 7.1 Top Three Ranked Industries in Clarkson Airshed Study Area in Terms of the Highest Contributors to Contaminant Concentrations Measured at Ministry Monitoring Stations..... 7-4

TABLE 7.2 Industry Source Contribution Matrix - $PM_{2.5}$ Measured 98th Percentile Concentrations for Top Three Individual Industries (µg/m3) 7-4

List of Figures

Clarkson Airshed Study:
Part III – The Air Quality Dispersion Modeling Source Contribution Assessment

NUMBER AND TITLE OF FIGURE		PAGE
FIGURE 2.1	Clarkson Airshed Study Area	2-3
FIGURE 3.1	Clarkson Airshed Modeling Domain	3-7
FIGURE 3.2	Identification of Postal Codes Used to Group Sources for Dispersion Modelling	3-8
FIGURE 3.3	Major Road Links Considered in the Clarkson Airshed Modeling Domain	3-9
FIGURE 4.1	Location of WRF Grid Points Used in the Development of Modeling Data for the Clarkson Airshed Study Area	4-6
FIGURE 4.2	Topographical Map of Clarkson Airshed Study Area CALMET Domain	4-7
FIGURE 4.3	Land Use Data in the CALMET Modeling Domain	4-8
FIGURE 4.4	CALMET Wind Rose – 2004 – Ministry Monitoring Station 44075	4-9
FIGURE 4.5	CALMET Wind Rose – 2004 – Sewage Treatment Plant	4-10
FIGURE 4.6	CALMET Wind Rose – 2004 – Toronto Pearson International Airport	4-11
FIGURE 4.7	CALPUFF Modeling Domain and Receptors Used in the Simulation	4-12
FIGURE 4.8	Location of Clarkson Airshed Ambient Air Monitoring Stations - Source Contribution Matrix Receptors	4-13

List of Figures

NUMBER AND TITLE OF FIGURE **PAGE**

FIGURE 5.1 Annual Average Predicted and 98th Percentile Measured PM_{10} Concentrations At Ministry Monitoring Stations ($\mu g/m^3$) 5-23

FIGURE 5.2 Annual Average Predicted and 98th Percentile Measured $PM_{2.5}$ Concentrations At Ministry Monitoring Stations ($\mu g/m^3$) 5-24

FIGURE 5.3 Annual Average Predicted and 98th Percentile Measured NO_x Concentrations At Ministry Monitoring Stations ($\mu g/m^3$) 5-25

FIGURE 5.4 Annual Average Predicted and 98th Percentile Measured VOC Concentrations At Ministry Monitoring Stations ($\mu g/m^3$) 5-26

FIGURE 5.5 Isopleth - Annual Average Predicted PM_{10} Concentrations ($\mu g/m^3$) 5-27

FIGURE 5.6 Isopleth - Annual Average Predicted $PM_{2.5}$ Concentrations ($\mu g/m^3$) 5-28

FIGURE 5.7 Isopleth - Annual Average Predicted NO_x Concentrations ($\mu g/m^3$) 5-29

FIGURE 5.8 Isopleth - Annual Average Predicted VOC Concentrations ($\mu g/m^3$) 5-30

FIGURE 5.9 Bias Analysis for Maximum 24 Hour Average Concentrations for PM_{10}, $PM_{2.5}$, NO_x and VOCs 5-31

FIGURE 5.10 Bias Analysis for Annual Average Concentrations for PM_{10}, $PM_{2.5}$, NO_x and VOCs 5-32

FIGURE 5.11 Q-Q Plots for $PM_{2.5}$ 24 Hour Concentrations 5-33

FIGURE 5.12 Q-Q Plots for NO_x 24 Hour Concentrations 5-33

FIGURE 6.1(a) Sulphates Measurements from USA “Improve” Network ($\mu g/m^3$) 6-2

FIGURE 6.1(b) Nitrates Measurements from USA “Improve” Network ($\mu g/m^3$) 6-3

Section - One

Glossary of Terms

Clarkson Airshed Study:
Part III – The Air Quality Dispersion Modeling Source Contribution Assessment

Airshed: a geographical region covered by a volume of air that has similar characteristics.

Air toxics: airborne pollutants that can cause health effects such as cancer, genetic mutations, organ damage, changes to the nervous system, or even physiological harm as a result of prolonged exposure, even in relatively small amounts

Ambient air: outdoor or open air.

CAS: Clarkson Airshed Study.

CALPUFF: Calpuff is a California Puff Model, which is approved for use by the US EPA as an atmospheric dispersion model. It is also one of the recommended models under O.Reg 419/05.

CALMET: Calmet is the pre-processor required for the meteorological data which is used in the Calpuff model.

Clarkson Airshed Study Area: This is the area of approximately 20 km x 20 km in which both Parts II and III of the Clarkson Airshed Study were focussed. It is located on the north shore of Lake Ontario surrounding the Town of Clarkson.

Fine Particulate Matter ($PM_{2.5}$): see "respirable particulate matter".

Inhalable Particulate Matter (PM_{10}): represent up to 60 per cent of the total suspended particulate matter; composed of both coarse particles (diameter 2.6 to 10.0 microns) and fine particles (diameter < 2.5 microns).

Micrometre or Micron: a millionth of a metre.

NAPS Network: NAPS is the National Air Pollution Surveillance monitoring program that is maintained by Environment Canada.

Nitrogen Dioxide (NO_2): a reddish-brown gas with a pungent and irritating odour.

Nitric Oxide (NO): a precursor of ozone, NO_2 and nitrate; nitric oxide is usually emitted from combustion processes; is converted to nitrogen dioxide (NO_2) in the atmosphere and then becomes involved in the photochemical processes and /or particulate formation.

Nitrogen Oxides (NO_x): generally considered to be the sum of NO and NO_2.

Particulate Matter: refers to all airborne finely divided solid or liquid material with an aerodynamic diameter smaller than 44 microns.

PPB: Parts per billion, a unit of measurement sometimes used when reporting the concentration of a pollutant. In this Report, one part per billion equals one part of the contaminant for every billion parts of air.

Respirable Particulate Matter ($PM_{2.5}$): particles smaller than about 2.5 microns in aerodynamic diameter, which arise mainly from condensation of hot vapours and chemically-driven gas-to-particle conversion processes; these particles are fine enough to penetrate deep into the lungs and have the greatest negative impact on human health (see also "fine particulate matter").

Smog: a contraction of smoke and fog; colloquial term used for photochemical pollution, which includes ozone and other contaminants; generally noticeable as a brownish haze.

Taxed airshed area: a geographical region covered by a volume of air that has similar characteristics and in which air quality is comprised of elevated levels of air contaminants.

Transboundary Air Pollution/Long Range Transport: Transboundary is the transport of pollutants across a defined boundary which in the case of the Canadian/US border is also referred to Long Range Transport. In this study, the transboundary air pollution is referred to the transport of air pollutants into the Clarkson Airshed study area.

Troposphere: atmospheric layer extending about 10 kilometres above the earth's surface.

Section - Two

Purpose of Study and Outline of Basic Approach

Clarkson Airshed Study: Part III – The Air Quality Dispersion Modeling Source Contribution Assessment

2.0 Introduction

The purpose of Part III of the Clarkson Airshed Study was to use the monitoring data developed in Part II of the study – "The Ambient Air Monitoring Program" (Ministry Report - Nov 2006) along with data generated from use of the CALMET/CALPUFF air dispersion modeling system, to determine the relative contributions of various air emission sources to the total contaminant concentrations measured at the six Part II Ministry air monitoring stations.

In considering the purpose of this Air Quality Dispersion Modeling Source Contribution Assessment, several key components were identified as a means of defining our approach to developing the appropriate source contribution data base. These components were:

(i) The definition of 4 source sectors – (a) Industrial (process stack emissions, process and vehicle/road dust fugitive emissions; (b) Vehicular (tailpipe and surface re-suspended road dust emissions from travel on public roadways); (c) Residential (heating) and; (d) Miscellaneous (a general category which may include such sources as: dry cleaning, fuel marketing, general solvent use, pesticides and fertilizer applications etc).

(ii) The selection of 10 individual industry sources located in the area considered as important contributors to sector emissions.

(iii) The identification of key contaminants of interest, namely: (a) particulate matter less than or equal to 10 microns in size (PM_{10}), (b) particulate matter less than or equal to 2.5 microns ($PM_{2.5}$), (c) nitrogen oxides (NO_x) and (d) total volatile organic compounds (VOCs).

(iv) The development of a comprehensive inventory of all significant air emissions sources located both within and in the vicinity of, the Clarkson Airshed study area.

(v) The use of the CALMET/CALPUFF dispersion modelling system (version 5.711a) to develop predicted contaminant concentrations and help define the contributions of the various source sectors to air quality in the airshed study area.

The initial step in the Part III assessment was the development of a comprehensive inventory of contaminant air emissions for all significant sources within the study domain as defined by the four specific source sectors and several individual industries.

The source emissions data was then inputted to the CALMET/CALPUFF air modelling system to predict ambient air contaminant concentrations at each of the six Ministry Part II air monitoring stations.

The concentrations predicted at the monitoring stations were compared to corresponding measured values obtained during the Part II ambient air monitoring program in order to investigate the "reasonableness" of the CALMET/CALPUFF dispersion modelling results.

Once it was clear that the predicted contaminant concentration data was reasonable, these values were used to calculate the contributions of the various source sectors and individual industries to the total measured concentrations at the Ministry monitoring stations.

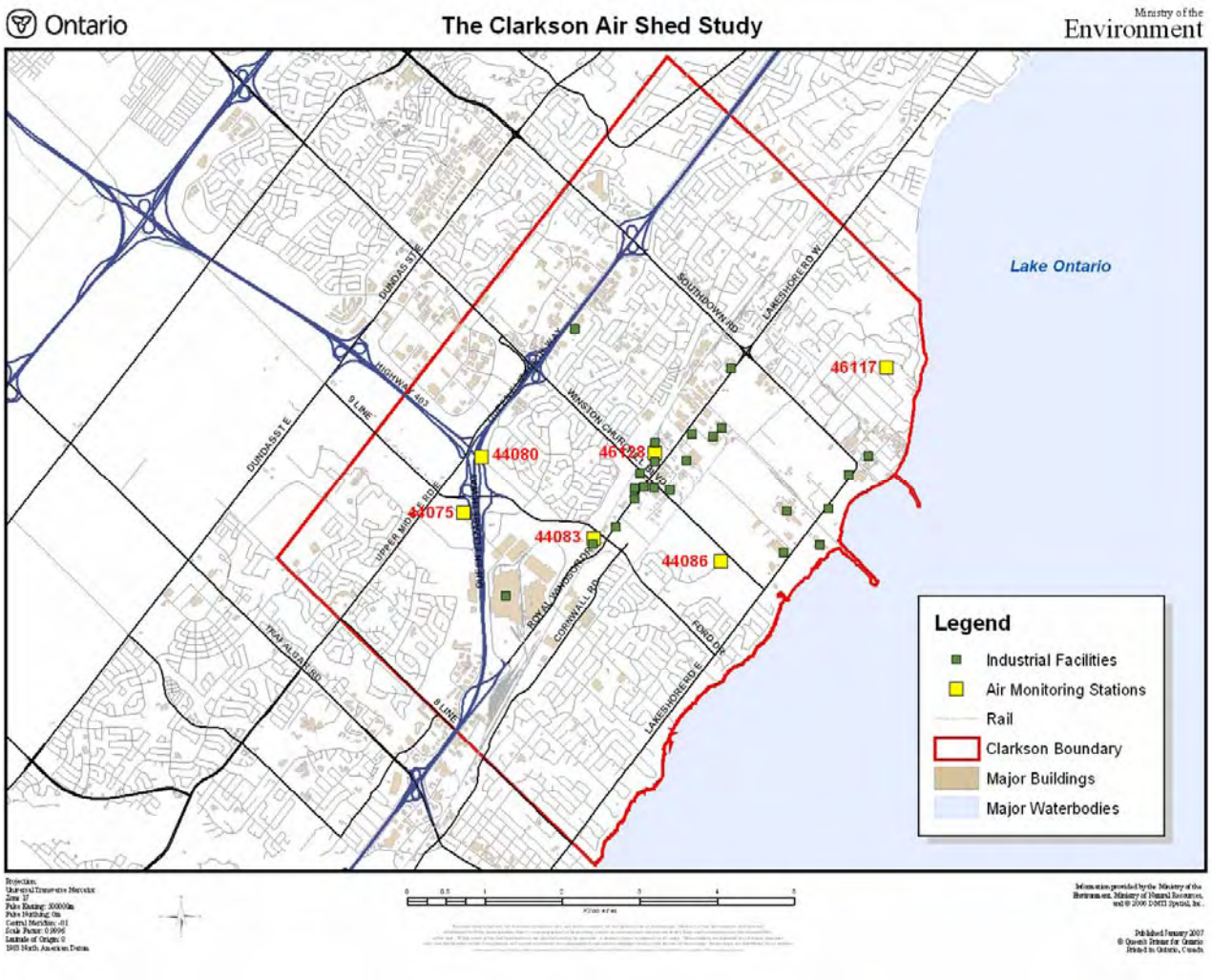
2.1 Study Area

The Clarkson Airshed study area, which encompasses an area of approximately 20 km x 20 km around the Town of Clarkson, is located on the north shore of Lake Ontario and is depicted in **Figure 2.1**.

2.2 Method of Assessment

This Section provides an outline of the approach which the Ministry used to: (i) develop the air emissions inventory; (ii) complete the atmospheric dispersion modeling; (iii) develop the measured source sector and individual industry contaminant concentrations and; (iv) produce the source contribution matrices.

Figure 2.1 Clarkson Airshed Study Area



2.2.1 The Selected Contaminants

The contaminants considered in the Part II assessment were:

(i) particulate matter less than or equal to 10 microns (µm) in size (PM_{10});

(ii) particulate matter less than or equal to 2.5 microns (µm) in size ($PM_{2.5}$);

(iii) nitrogen oxides (NO_x); and

(iv) total volatile organic compounds (VOCs).

It should be emphasized that the Part II Ambient Air Monitoring Program also included measurements of total suspended particulate (TSP); however, due to the incomplete emission data base for TSP, this contaminant was not considered in Part III.

2.2.2 Air Emissions Inventory

Various air emission data bases were examined and combined for use in this assessment. The primary sources of the emission data were the Ministry's Regulation 127 and National Pollutant Release Inventory (NPRI) submissions as well as Environment Canada's Criteria Air Contaminants (CAC) emission databases. In addition, emission estimates and AERMOD dispersion modeling data were provided by the individual industries located in the Clarkson Airshed study area.

As noted in our introductory discussions to this Section, many different sources within the Clarkson Airshed study area contribute to the local air quality including local industrial sources, automotive/vehicular sources, emissions from residential heating and others. In total, 412 study area sources where characterized for the air dispersion modeling exercise.

In addition, two significant sources on either side of the Clarkson Airshed study area namely, Lakeview Generating Station and the Petro Canada Oakville Refinery, were also evaluated to determine what their inputs to the area's air quality may be.

Traffic information was obtained from the University of Toronto Data Management Group (DMG) (UofT, 2006) and used to develop the vehicular daily traffic profiles. This information was, in turn, used with the model MOBILE 6.2C (Taylor, 2003) emissions to prepare vehicular emission inputs for this modeling assessment relative to vehicle travel on public roadways.

2.2.3 Air Dispersion/Meteorological Modeling

For this assessment, the air dispersion modelling was undertaken using the CALMET/CALPUFF (Version 5.711a) modeling system (Scire, 2000). The CALMET/CALPUFF modeling system is a U.S. EPA regulatory model which is used to simulate atmospheric dispersion of pollutants and calculate air concentrations downwind of emission sources. CALMET is the meteorological component of the modeling system that produces hourly three dimensional wind fields from available meteorological, terrain and land use data. CALPUFF is a non-steady state, puff dispersion model that uses the CALMET wind fields and accounts for spatial changes in meteorology, variable surface conditions, and plume interactions with terrain.

2.2.4 Source Sector Measured Concentrations and Industry Source Contribution Matrices

The results from the use of the CALMET/CALPUFF Modeling System were defined for each of the four source sectors and each of the 10 individual industries based on predicted contaminant concentrations at each of the six Ministry monitoring stations.

Using ratios of total measured to predicted results for each monitoring station, measured contaminant concentrations were determined for each of the four source sectors and each of the 10 individual industries. The latter were identified as the Industry Source Contribution Matrices and were developed for each of the four contaminants evaluated.

It is important to acknowledge at this point that the focus of this approach in terms of measured contaminant concentrations was on 2004 data (both annual average 24 hour values and 98th percentile values) since 2004 represented the only full year during which the Ministry carried out its Part II studies.

Section - Three

Inventory of Contaminant Emissions

Clarkson Airshed Study: Part III – The Air Quality Dispersion Modeling Source Contribution Assessment

3.0 Introduction

An emission inventory is an accounting of the quantity and rate [typically in grams per second (g/s) and tonnes/year] of contaminants emitted to the atmosphere from various sources.

In the Part III assessment, two specific inventories have been prepared in order to address the key dispersion modeling objectives. These inventories were: (a) the inventory of contaminant emissions for the four source sectors (Industrial, Vehicular, Residential and Miscellaneous); and (b) the inventory of contaminant emissions for 10 individual industries that operate within the Clarkson Airshed study area.

The contaminants of concern in developing both emissions inventories were: (i) PM_{10}; (ii) $PM_{2.5}$; (iii) NO_x and, (iv) VOCs as noted in Section 2.2.1 of the report.

In addressing the above mentioned source sectors, the Ministry considered emissions from numerous 'types' of sources, namely: (i) point sources such as industry stacks, (ii) line sources such as public roadways and, (iii) fugitive sources (in terms of both volume and areas).

It is well known that sources of emissions from outside of the study area, including for example sources as far away as the Ohio Valley [Long-Range Transport of air pollutants], contribute to local air quality. This aspect of emissions sources is not covered in this Section but is dealt with in Section 6 of the Report.

3.1 Emissions – Industry Point Sources/Stacks

Pollutant concentrations and relevant physical stack parameters (diameter, temperature, flow rate, height) were provided by individual industries for 202 process stacks located in the study area. In total, 10 industrial facilities were captured in this portion of the source emission database.

The emission inputs for industrial point sources were prorated using Ministry Regulation 127 and National Pollutant Release Inventory (NPRI) submissions for 2004. The stack parameters, including stack location and stack diameter were based on the individual facility Emission Summary and Dispersion Modeling (ESDM) input files. A visual screening was used to qualitatively confirm the "reasonableness" of the stack locations.

Emissions from other industry sources in the study area were obtained from the Environment Canada Criteria Air Contaminant (CAC) emission data base.

Table A.1 of Appendix A presents the information for the industry process stacks included in the source emissions inventory, along with the stack parameters and pollutant emission rates. The data shown in this table were used as input to the CALPUFF air dispersion model in order to determine the relative impact of these sources at all six of the Ministry's air monitoring stations in the Clarkson Airshed study area.

Figure 3.1 illustrates the extent to which emission inventories were needed and how they were incorporated into the "Clarkson Airshed Modeling Domain".

In addition to showing the locations of some of the specific industrial sources considered in this assessment, **Figure 3.1** also shows the locations of meteorological stations and the Ministry monitoring stations in the study area. Finally, the figure also shows the domain boundaries used for the meteorological simulation and for the actual CALPUFF modeling.

The CALMET model was run over a modeling domain of 35 km in east-west direction and 35 km in south-north direction. This domain was noticeably larger than that used for air dispersion modeling. This was done to help minimize numerical effects that may influence the forecasting of meteorological parameters particularly at domain boundaries. The CALPUFF modeling domain was smaller (~ 20 by 20 km) and situated away from the edges of the CALMET domain.

3.2 Emissions – Industry "Fugitive"

Fugitive emissions from industrial facilities are defined as those emissions attributable to industrial operations but not released from a stack. Such emissions are generally released from processes or activities and that may be the result of equipment leaks, evaporative processes and/or windblown disturbances.

The industry fugitive sources included in the Clarkson Airshed Part III dispersion modeling exercise were considered as: (i) area sources (parking lots) or, (ii) volume sources (emissions associated with general ventilation exhaust from an operations building and re-suspended road dust from paved and unpaved industry roads).

Re-suspended road dust (characterized as PM_{10} and $PM_{2.5}$) from paved and unpaved industry "on-site" roads can contribute a measurable amount to a total site inventory. Content of this dust/particulate matter is also inherently variable and related to the nature of the specific industrial operations on which the on-site roads are located. Consequently, in order to simplify the CALPUFF input complexity and the number of sources which have to be simulated, these sources were treated as a single volume source for each industry and included as part of the Industrial source sector.

Emissions of $PM_{2.5}$, NO_x and VOCs from on-site (industry) vehicular traffic tailpipes were estimated by using Ministry of Transportation (MTO) data from public roads. It is important to note that on-site vehicular tailpipe emissions were expected to be very minor when compared to tailpipe emissions from "off-site" roadways and even less significant when added to industrial fugitive emissions.

Re-suspended road dust emissions from paved and non-paved surfaces of industry on-site roadways were calculated using U.S. EPA AP 42 emission factors.

3.3 Emissions – Vehicular (Public Roadways)

Vehicular emissions that include emissions from vehicle tailpipes and re-suspended road dust from vehicle travel on public roads, were also modeled as fugitive sources.

Detailed vehicle counts by vehicle class were available from the University of Toronto – Data Management Group (DMG) (UofT, 2006), and hourly vehicle profiles were developed for the major road links in the Clarkson Airshed study area (**Figure 3.3**). This information was used to calculate vehicle tailpipe emissions from the major road links.

Vehicular emissions related to travel on roads other than the major road links were calculated in terms of the appropriate Postal Code area sources presented in **Figure 3.2**. The actual shapes of the various Postal Code areas were approximated by combinations of rectangular areas sources of 1000m x 1000m in size.

Re-suspended road dust emissions from paved and unpaved road surfaces of major road links in the study area were calculated using U.S. EPA AP42 emission factors.

3.4 Emissions - Residential

These emissions originate primarily from home heating sources. The data were extracted from the Environment Canada data base (CAC) and assigned to the appropriate Postal Code area.

3.5 Emissions - Miscellaneous

This sector was based on the Environment Canada definition of miscellaneous and includes emissions from: cigarette smoking, dry cleaning, fuel marketing, general solvent use, pesticides and fertilizer application, printing, structural fires, surface coatings and meat cooking. These data were also extracted from the Environment Canada CAC data base and were assigned to the appropriate Postal Code area.

3.6 Results - Total Source Sector Emission Data

Table 3.1 presents a summary of all emissions for the Clarkson Airshed study area (20 by 20 km) modeling domain. It is important to note, as mentioned in Section 2.0 of the Report, that the emissions data presented focus on the year 2004 since, for comparative purposes, this is the only complete year for which ambient air monitoring data was available from Part II of the Clarkson Airshed Study.

The Ministry's Part II Clarkson Airshed Ambient Air Monitoring Program identified 22 industries as "significant emitters". Based on available data, 10 of these 22 individual industrial emitters were selected for a more detailed evaluation. A summary of contaminant emissions for these industries are shown in **Table 3.2**.

From a comparison of **Tables 3.1 and 3.2**, the 10 individual industries contribute about 4% of PM_{10}, 4% of $PM_{2.5}$, 8% of NO_x and 5% of VOCs to the ambient air quality in the Clarkson Airshed study area.

Table 3.1 Summary of Source Sector Emissions – 2004 (Tonnes/Year)

SOURCE TYPE	PM_{10}	PM_{25}	NO_X [4]	VOC
Industry				
Industrial Stacks (Total from Table 3.2)	338.4	180.5	2060.0	1997.5
Industrial Volume Sources	344.6	166.6	620.4	736.8
Industrial Area Sources	2.1	0.5	0.0	0.0
Industrial Fugitive Emissions (by Postal Codes)[1]	1685	1422.5	13280.5	3770.6
Industrial Total	**2370.1**	**1770.1**	**15960.9**	**6504.9**
Vehicular – Main Links	968.4	243.7	1691.6	288.5
Vehicular Fugitive Emissions (by Postal Codes)	4495.6	1508.2	8156.2	4302.8
Vehicular [2]	**5464.1**	**1751.9**	**9847.8**	**4591.3**
Residential	**997.1**	**994.1**	**704.9**	**1356.6**
Miscellaneous [3]	**329.7**	**37.6**	**0.0**	**30832.0**
TOTAL	**9161.0**	**4554.7**	**26513.6**	**43284.8**

Notes:

1. The 10 Individual Industries were subtracted from the totals reported under NPRI CAC postal code database. However, the totals include significant sources outside of the Clarkson Airshed study area, such as Lakeview Generating Station and Petro Canada Refinery.
2. Vehicular Emissions includes the main highways and major roads and the NPRI CAC postal code database.
3. The miscellaneous category under the NPRI CAC database includes fugitive sources from construction sites, open pits, etc. The fugitive dust and fugitive VOCs emissions were over-estimated in the CAC database. Based on the model validation, it was assumed 0.1% of the total PM_{10} and $PM_{2.5}$ emissions and 1.0% of the total VOCs reported would be used in the Part III assessment.
4. NOx emissions for Industry Stacks and Vehicular are reported as NO and the remaining is NO_2. However, for simplicity the above emissions were entered into Calpuff as NOx emissions.

Table 3.2 Summary of Total Emissions From Selected Individual Industries – 2004 (Tonnes/Year)*

COMPANY NUMBER	COMPANY NAME	PM_{10} Total	$PM_{2.5}$ Total	NO_x[1] Total	VOC Total
1	Westroc Inc	0.71	0.70	BT	23.00
2	Universal Drum	1.20	0.41	BT	119.66
3	PPG Canada Inc.	BT	BT	2.80	99.94
4	Ashland Chemicals [2]				18.12
5	Ford Motor Company of Canada	26.65	5.43	35.67	534.33
	Ford Motor Company of Canada - Truck	12.52	2.48	16.03	174.83
	Ford Total	39.16	7.91	51.69	709.16
6	Orion Bus Industries	1.09	0.47	BT	73.03
7	Petro Canada Lubricants	74.24	54.68	484.37	198.08
8	St. Lawrence Cement	68.31	33.70	1470.0	35.72
9	Stackpole Limited	14.73	7.35	0.00	11.60
10	Royal Ready Mix [3]	0.84	0.20	0.07	0.00
	TOTAL	**338.39**	**180.49**	**2060.62**	**1997.48**

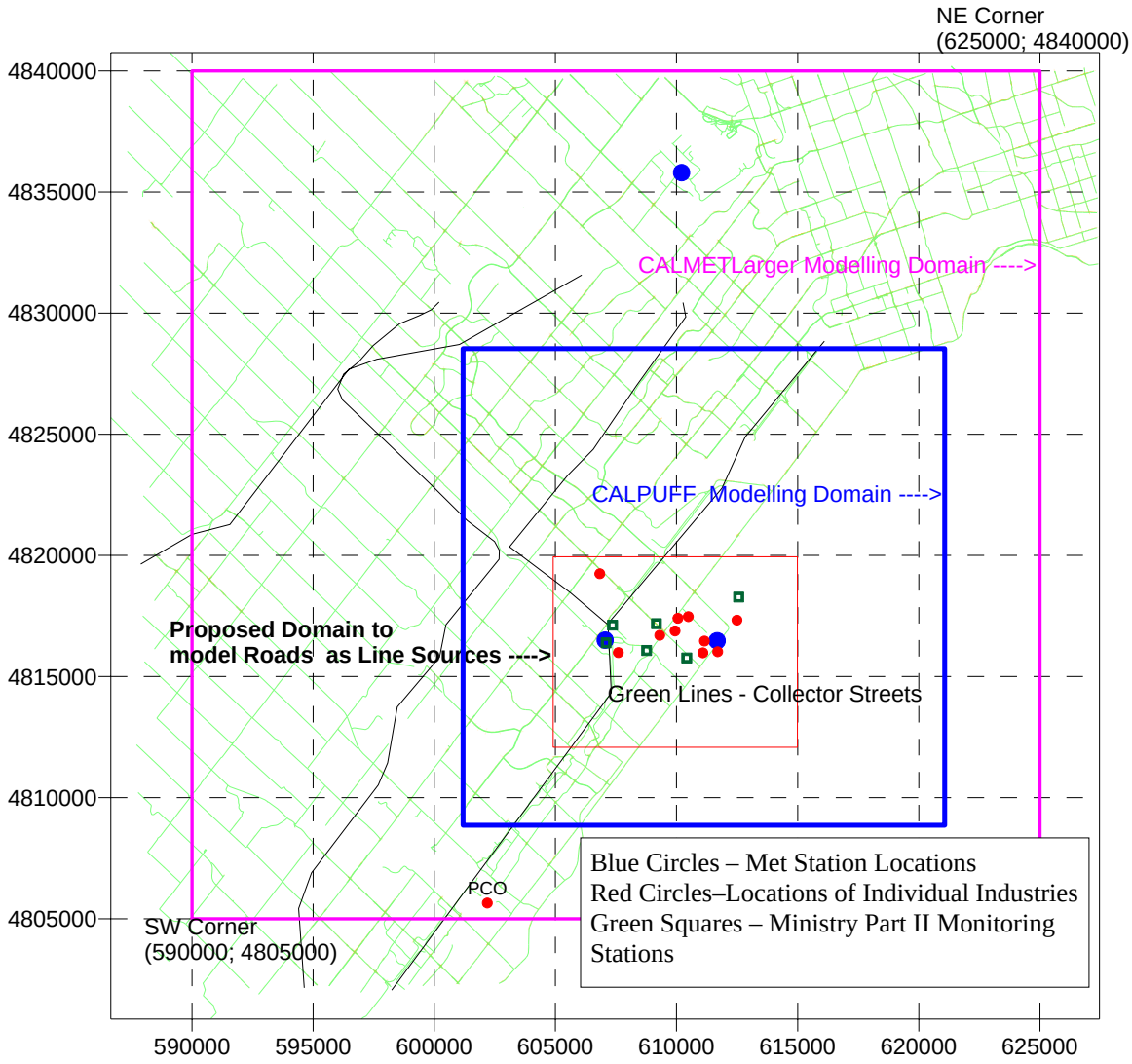
Notes:

* BT (Below Reporting Threshold), hence no emissions data are available from NPRI's 2004 database. In this case, emissions from the facility's ESDM were used instead.

Emissions from the above mentioned industries are modelled as point sources in Clarkson Airshed study area, except those that were not reported which are captured under the area sources (postal codes).

1. NOx is reported as Nitrogen Oxide (NO).
2. Ashland emissions were modelled as volume sources and not as point sources, for this reason it is not included in Appendix A.
3. Royal Ready Mix was modelled as a unit emission rate and pro-rated with NPRI's 2004 emissions.

Figure 3.1 Clarkson Airshed Modeling Domain



Note: In the above figure, a 6th monitoring station [green square] is located at the exact same point as the most westerly blue circle.

Figure 3.2 Identification of Postal Codes Used To Group Sources For Dispersion Modeling

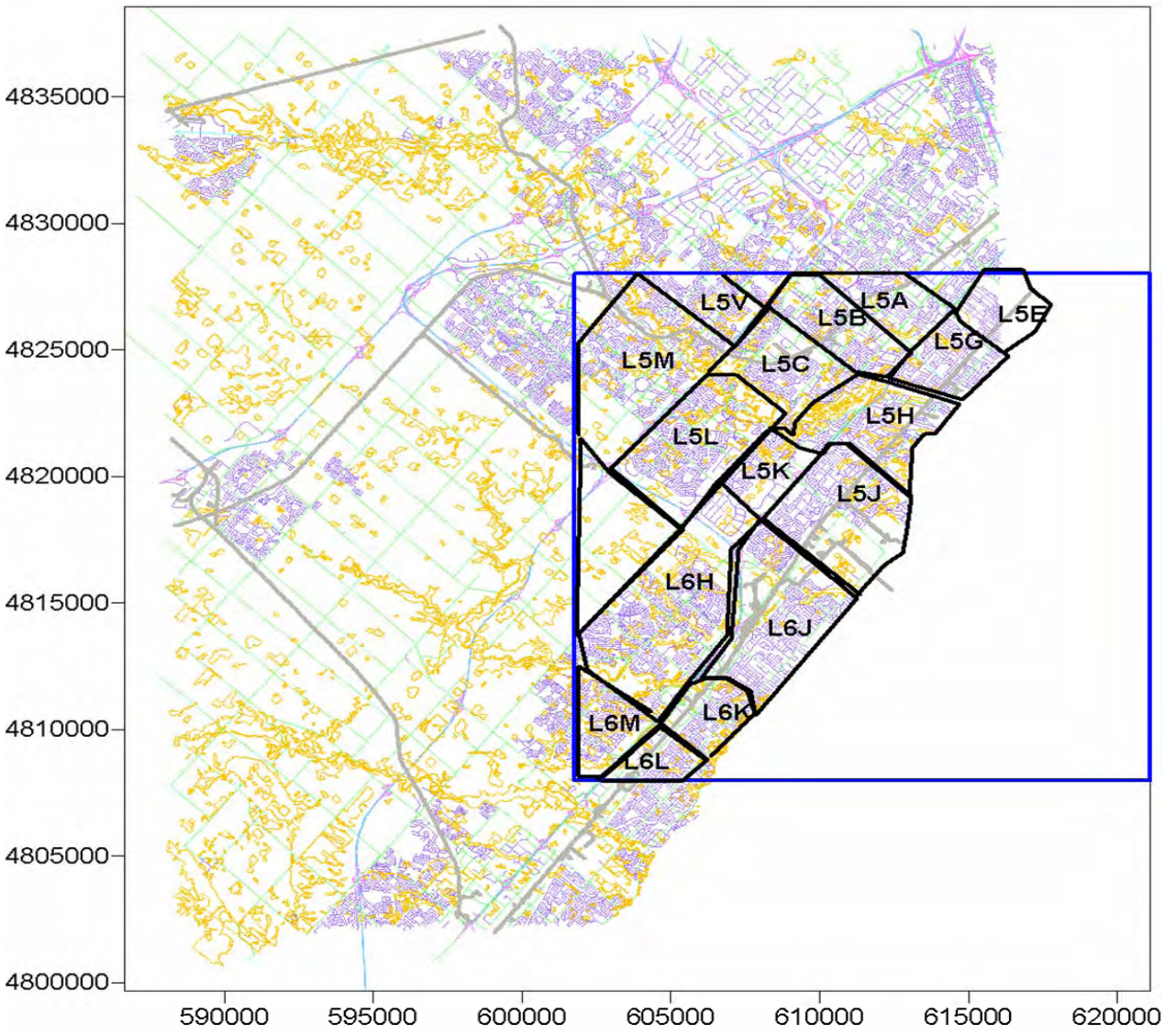
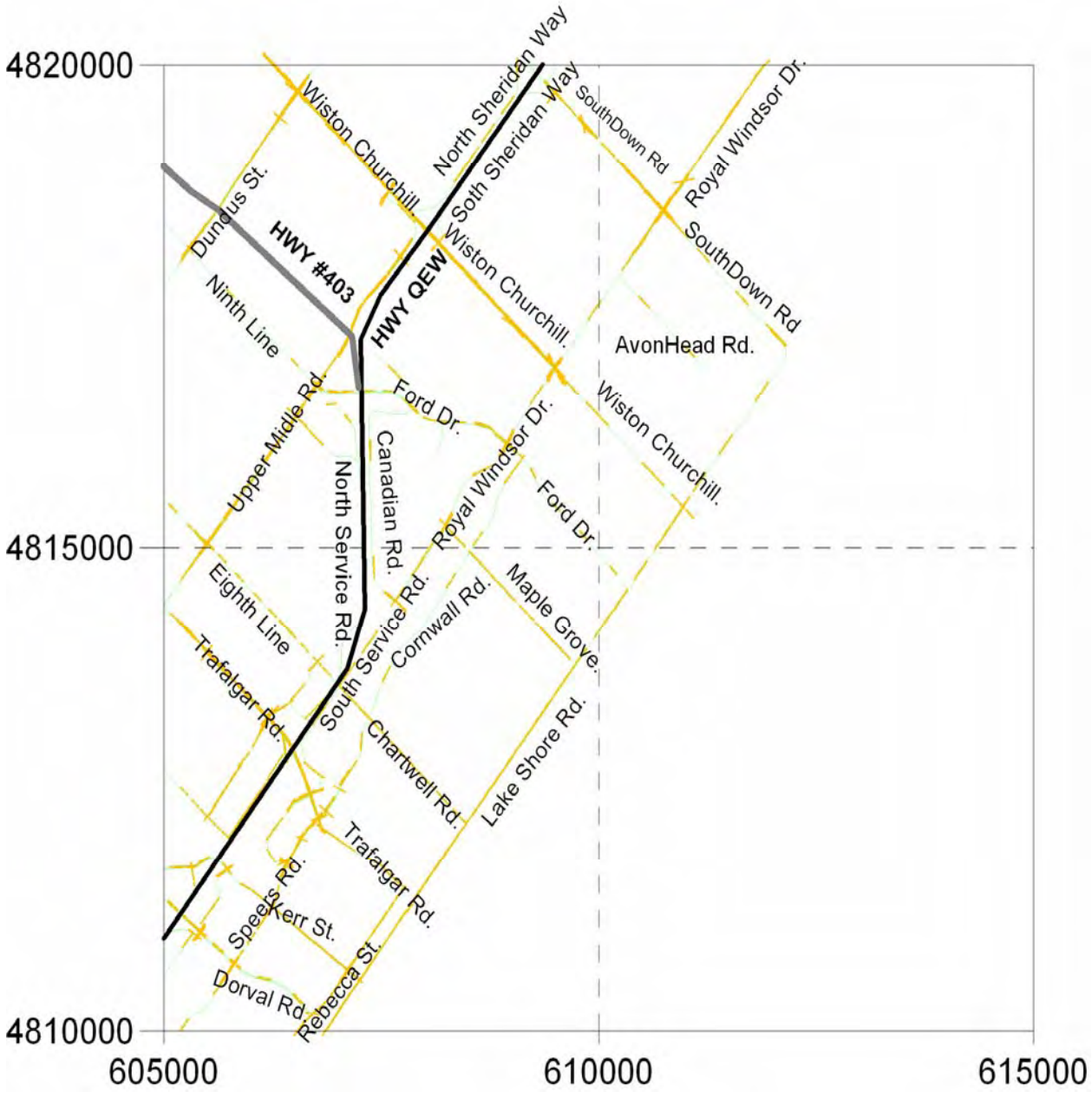


Figure 3.3 Major Road Links Considered in the Clarkson Airshed Modeling Domain



Note: In Figure 3.3 above, the street noted as "Wiston Churchill" is, in fact, "Winston Churchill Blvd."

Section - Four

Air Dispersion Modeling Methodology

Clarkson Airshed Study: Part III – The Air Quality Dispersion Modeling Source Contribution Assessment

4.0 Introduction – Model Selection

The Part III Air Quality Dispersion Modeling Source Contribution Assessment was undertaken using the CALMET/CALPUFF (Version 5.711a) modeling system and was applied to monitoring data from the year 2004 only. This air quality dispersion modeling system was chosen since it is better able to handle complex meteorology arising from water-land interactions that occur in the Clarkson Airshed study area. The simpler regulatory models such as ISC3Prime or AERMOD (two of the current air dispersion models acknowledged by the Ministry under Reg. 419) are not applicable when dealing with airshed applications such as in this case.

CALMET is the meteorological component of the modeling system that produces hourly, three dimensional gridded wind fields from available meteorological, terrain and land use data. In the Part III assessment and as described in the following section, CALMET input was derived from Ministry three dimensional wind field data calculated using the WRF[1] meso-scale meteorological model.

CALPUFF is a non-steady state puff dispersion model that uses the CALMET wind fields and accounts for spatial changes in meteorology, variable surface conditions, and complex terrain features including water-land interactions.

4.1 Meso-Scale Meteorology

Although meteorological data was available from the Pearson International Airport and other regional stations to accommodate Clarkson Airshed Part II Ambient Air Monitoring Program

1 – Weather Research and Forecasting

conducted by the Ministry (during the period of June 2003 to March 2005), these data were not adequate for the detailed modeling needed for this part of the study. Since the study area is located adjacent to a large body of water (Lake Ontario) and lake-water interactions complicate atmospheric processes, it was decided to develop meteorological data on a fine spatial scale to conduct the modeling.

In this regard, the Ministry generated the required three-dimensional (meso-scale) meteorological data using an innovative method of coupling the WRF-Scientific Version of meso-scale weather forecasting model (NCAR[1] Version), with the United States Environmental Protection Agency (U.S. EPA) regulatory CALMET/CALPUFF air dispersion modeling system. For this task, meso-scale modeling runs were carried out to generate wind fields over a 4 by 4 km grid from 12 by 12 Eta[2] analysis fields. The initial wind fields from the WRF meso-scale model were prepared in the format of pseudo surface observation and upper air observation points. This allowed the Ministry to generate site-specific meteorological data where no suitable data on an appropriate scale existed.

The six grid points that were chosen as surface stations are shown in **Figure 4.1**. The grid points as noted in the Figure are: (12,12), (12,13), (13,12), (13,13), (13,15) and (13,16). Six points were chosen because the wind fields derived from the meso-scale model were quite uniform and it was considered that using additional points would not make an appreciable difference in the final input of three dimensional windfields to CALMET. For the upper air pseudo-observations, grid point (13,12) was selected. Lake temperature was created from the Eta analysis fields. The three dimensional wind fields that were generated as the result of the meso-scale runs were reformatted as pseudo-surface and pseudo-upper air observations and used as input to the CALMET model.

4.2 CALMET Meteorological Model

The meteorological data developed from the fine resolution Ministry WRF modeling domain were used as one of the inputs into the CALMET meteorological pre-processor. CALMET further refined the meteorological data and created three-dimensional wind fields around the structures in the Clarkson Airshed study area modeling domain. Processing the available data through the CALMET meteorological processor model captured the regional flow patterns.

Hourly wind fields were prepared for use in the CALPUFF dispersion model for the year 2004. As noted in Section 3.1 of this report, the CALMET model was run over a modelling domain of 35 km in an east-west direction and 35 km in a south-north direction, with a grid spacing of 0.2

[1] NCAR – National Center for Atmospheric Research.

[2] Eta – Represents the greek letter η and is the name of Meso-scale Model based on Eta(η) vertical coordinate.

km. The CALMET model was run over a larger domain than was actually used for air dispersion modeling (20 km by 20 km). This was done to help minimize numerical effects that may influence the forecasting of meteorological parameters particularly at domain boundaries.

4.2.1 Wind Field Layer Heights

Nine vertical layers were included for the wind field. The layer heights are shown in **Table 4.1**.

Table 4.1 CALMET Wind Field Layer Heights

Vertical Height of Layer (m)	Layer Height of Top (m)
20	20
30	50
25	75
25	100
100	200
300	500
500	1000
1000	2000
1300	3300

4.2.2 Terrain Data

Terrain data for the modeling domain were processed through the TERREL CALMET pre-processor. Satellite data sampled at 3 arc-seconds (~90 m) resolution) were used as input.

Figure 4.2 presents the extent of the CALMET modeling domain with topographic data that were used as input into CALMET.

4.2.3 Land Use Data

Land use data, specific to the study area, were not available in an electronic format. Consequently, for this study, the land use map developed by the National Research Council of Canada (NRC) was used. NRC's data were transformed as needed for input to CALMET. Due to the nature of the urban category in the modeling domain, the default CALMET value of 1 m was changed to 0.5 m as it was considered more representative for the Clarkson study area's urban single home residential layout.

After processing input data through CALMET, the QALANDUSE gridded file was used to generate the land use data shown in **Figure 4.3** as a quality assurance check to confirm that the data were correctly entered and processed.

4.2.4 Performance of Meteorological Models

The performance of the meteorological models was examined with the help of wind rose diagrams. Wind speed and wind direction data were extracted from the CALMET grid points closest to three monitoring meteorological stations where hourly observations were available. These three locations were: (i) the Ministry Clarkson Airshed Part II monitoring station 44075; (ii) the Clarkson Sewage Treatment Plant (covering period July-December, 2004) and; (iii) the Toronto Pearson Airport. The Clarkson Sewage Treatment Plant data were blended with Toronto Island Airport for the period January-June, 2004 in order to provide a full year of coverage. **Figures 4.4** through **4.6** present the wind roses comparing observation data versus CALMET simulated data.

A visual comparison of the wind roses shows that overall, the performance of the coupled CALMET and MOE-WRF models was quite good, especially at the meteorological stations located at the nearby Sewage Treatment Plant and at Toronto Pearson Airport. Modeling at the third meteorological station location [Ministry air monitoring station # 44075] indicates that wind speeds are higher in the model than were measured. This is thought to arise from local terrain features in the immediate vicinity of this station.

4.3 CALMET/CALPUFF Modeling System

4.3.1 Modeling Domains and Receptor Grids

Figure 4.7 depicts the CALPUFF modeling domain that extends ~10 km in all directions from an approximated centre of the Clarkson Airshed study area. In addition to modeling contaminant concentrations at the six Ministry ambient air monitoring stations, isopleths (lines of equal concentration) were also developed [See Section 5.0 of the Report].

The isopleths were developed with as coarse a grid as was necessary to accommodate the large number of sources that needed to be modeled. The total of 412 sources were comprised of 202 point sources, 84 area sources, 43 line sources and 83 volume sources. In order to define the isopleths, selected receptors (over and above the six Part II monitoring station sites) are presented in **Figure 4.7** (green crosses). Notwithstanding their use in developing the isopleths, the patterns they depict are thought to reasonably illustrate the general patterns of air contaminant concentrations existing within the Clarkson Airshed study area.

4.3.2 Modeled Source Locations

The locations of the point sources, road/line sources and area sources (Postal Codes) were presented in Section 3.0 of the Report depicted in **Figures 3.1, 3.2 and 3.3**, respectively.

4.3.3 Discrete Receptors – Ministry Monitoring Stations

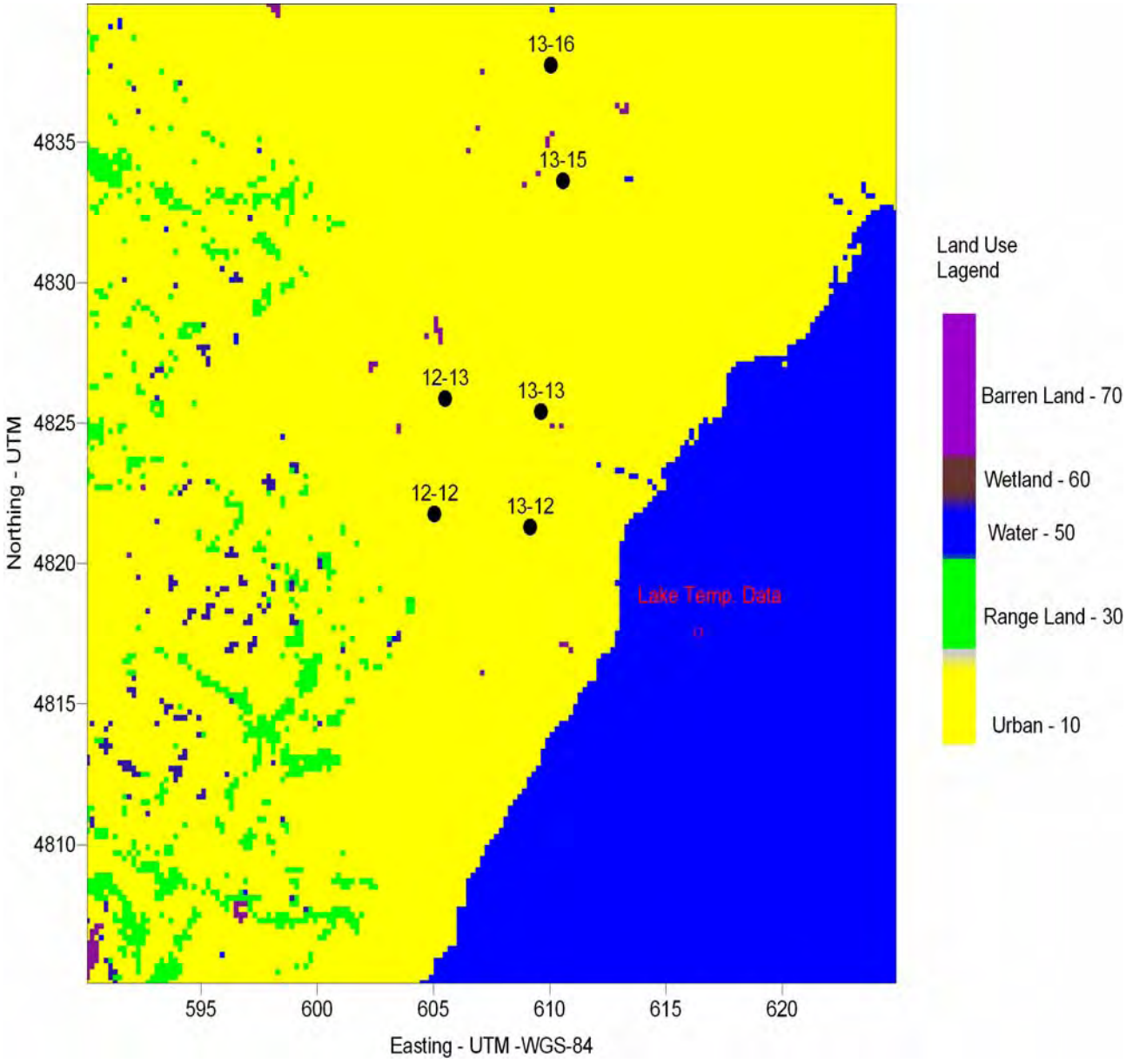
For the purposes of this assessment, results predicted from the dispersion model were examined at the six Ministry ambient air monitoring stations to support comparison of predicted data with measured data collected during Part II of the Clarkson Airshed Study. These six monitoring stations were used in the development of Source Contribution Matrices for the source sectors as a whole and for the ten individual industries.

The discrete receptors representing the Ministry's ambient monitoring stations are shown in **Figure 4.8** and the actual coordinates and receptor names are provided in **Table 4.2**.

Table 4.2 Summary of Receptor/Monitoring Stations Names and Coordinates

Station Name	Station Location	Monitoring Station Number	Coordinates		Comments on Monitoring Station Location
			Easting (m)	Northing (m)	
Stn. QEW West	9th Line and North of QEW, Oakville	44075	607092	4816391	Background Upwind QEW
Stn. QEW East	MTO Rd., South Sheridan Way and QEW, Oakville	44080	607359	4817122	Traffic Assessment Downwind QEW
Stn. Ford Dr.	South of Ford Dr., West of Royal Windsor Dr.	44083	608767	4816077	Downwind Major Industry
Stn. Residential	Deer Run, West of Winston Churchill Blvd., Oakville	44086	610424	4815767	Residential Background
Stn. Industrial Centre	Royal Windsor Dr. and Winston Churchill Blvd, Oakville	46128	609173	4817184	Industrial Area Clarkson Airshed
Stn. Industrial East	Meadow Wood Park and East of Southdown, Mississauga	46117	612566	4818278	Downwind Industrial Area

Figure 4.1 Location of WRF[1] Grid Points Used in the Development of Modeling Data For the Clarkson Airshed Study Area



1 - Weather Research and Forecasting

Figure 4.2 Topographical Map of Clarkson Airshed Study Area CALMET Domain

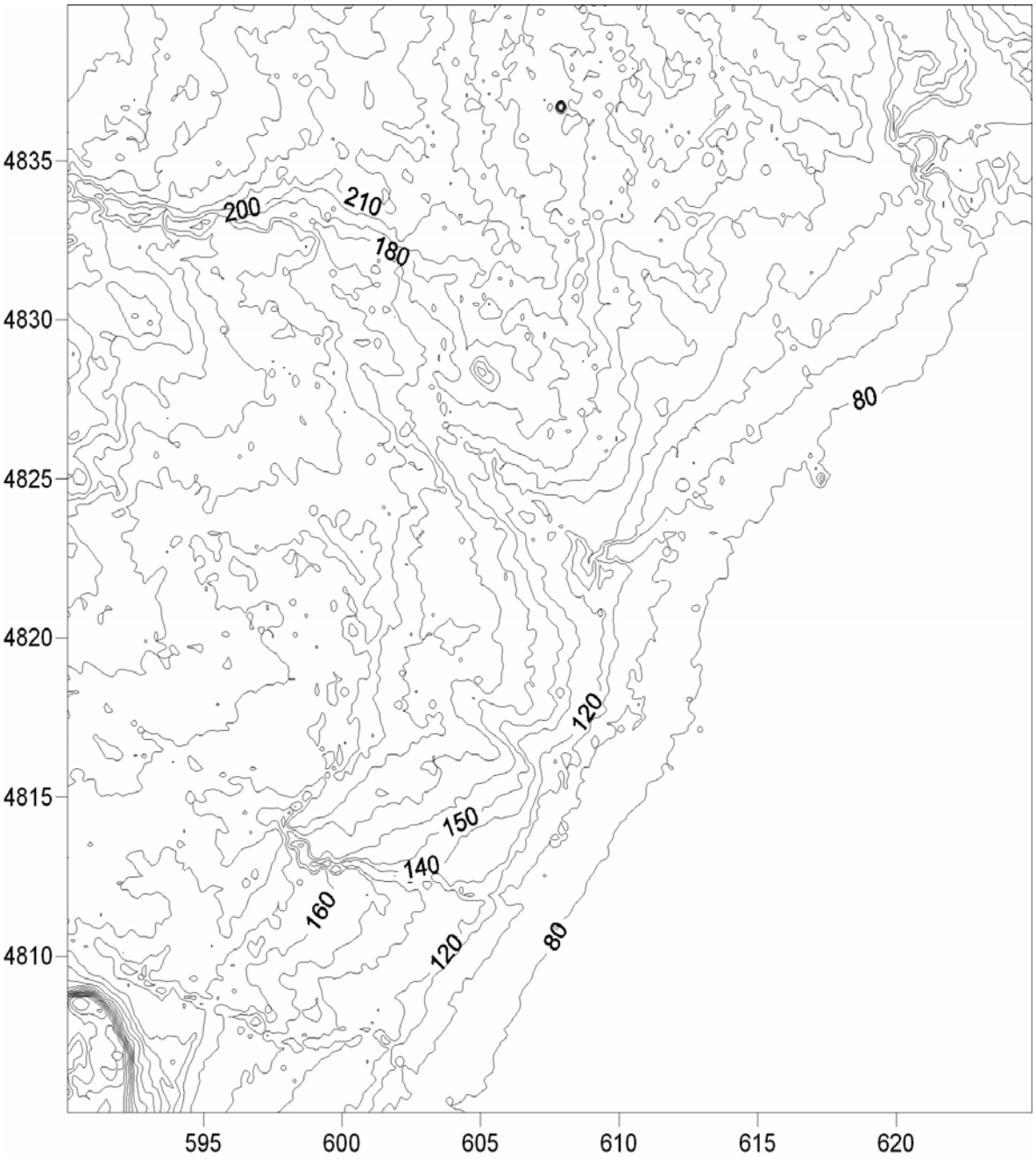


Figure 4.3 Land Use Data in the Clarkson Airshed Study Area CALMET Modeling Domain

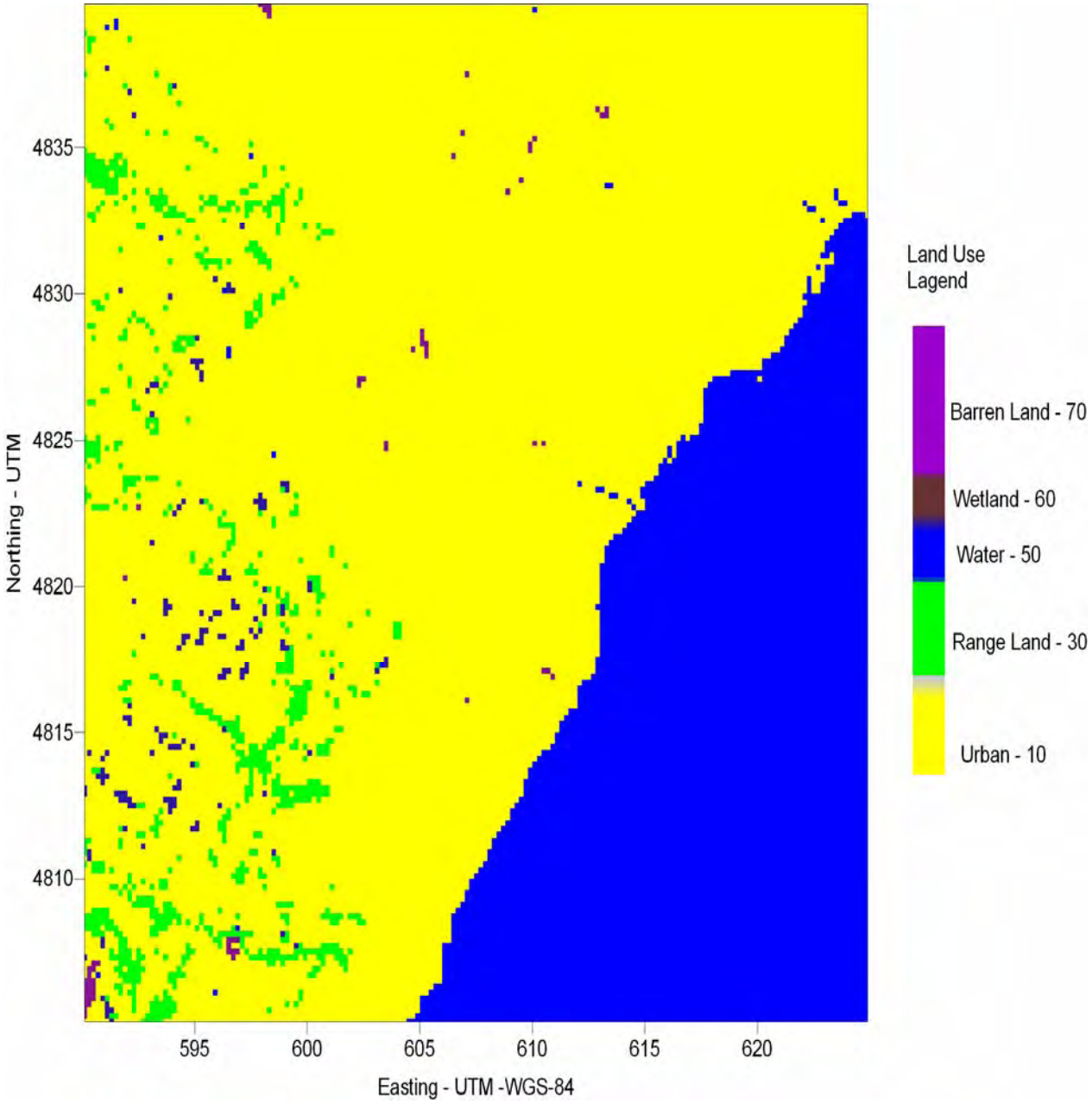
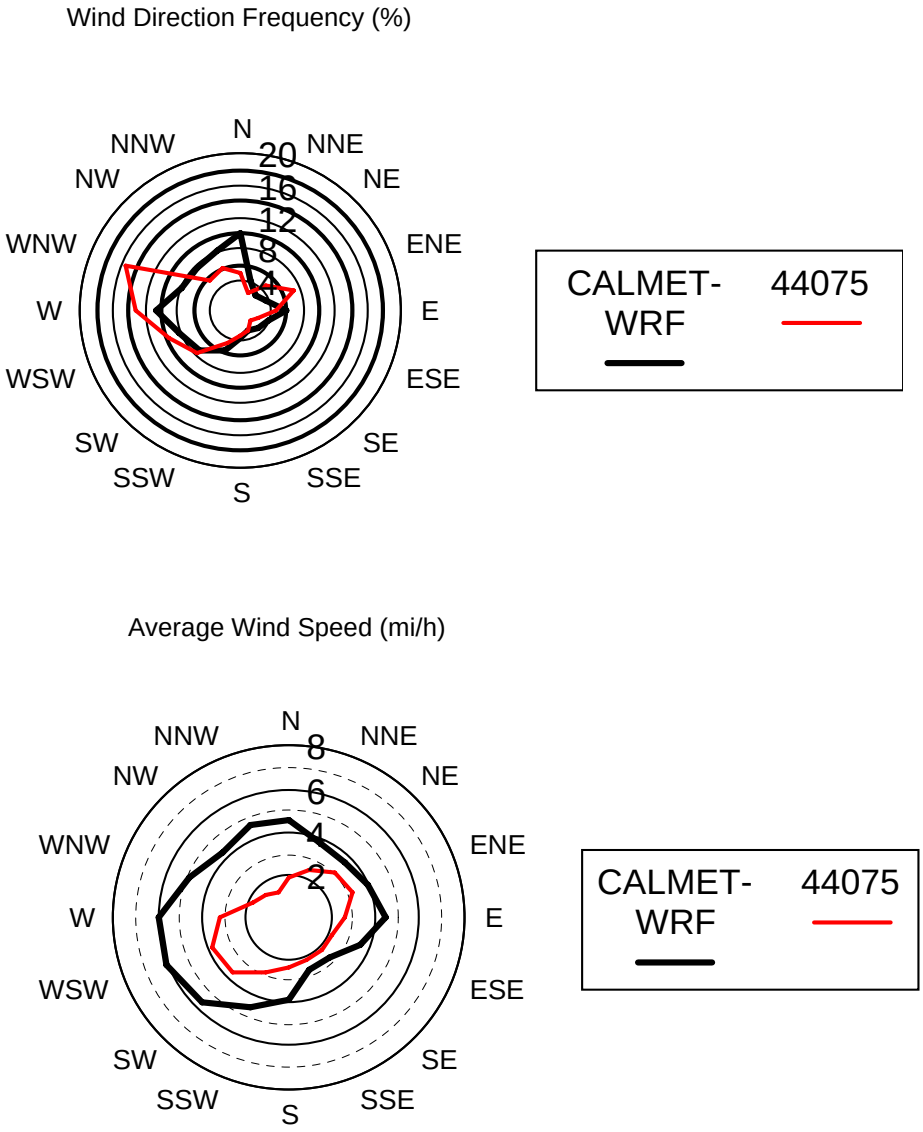
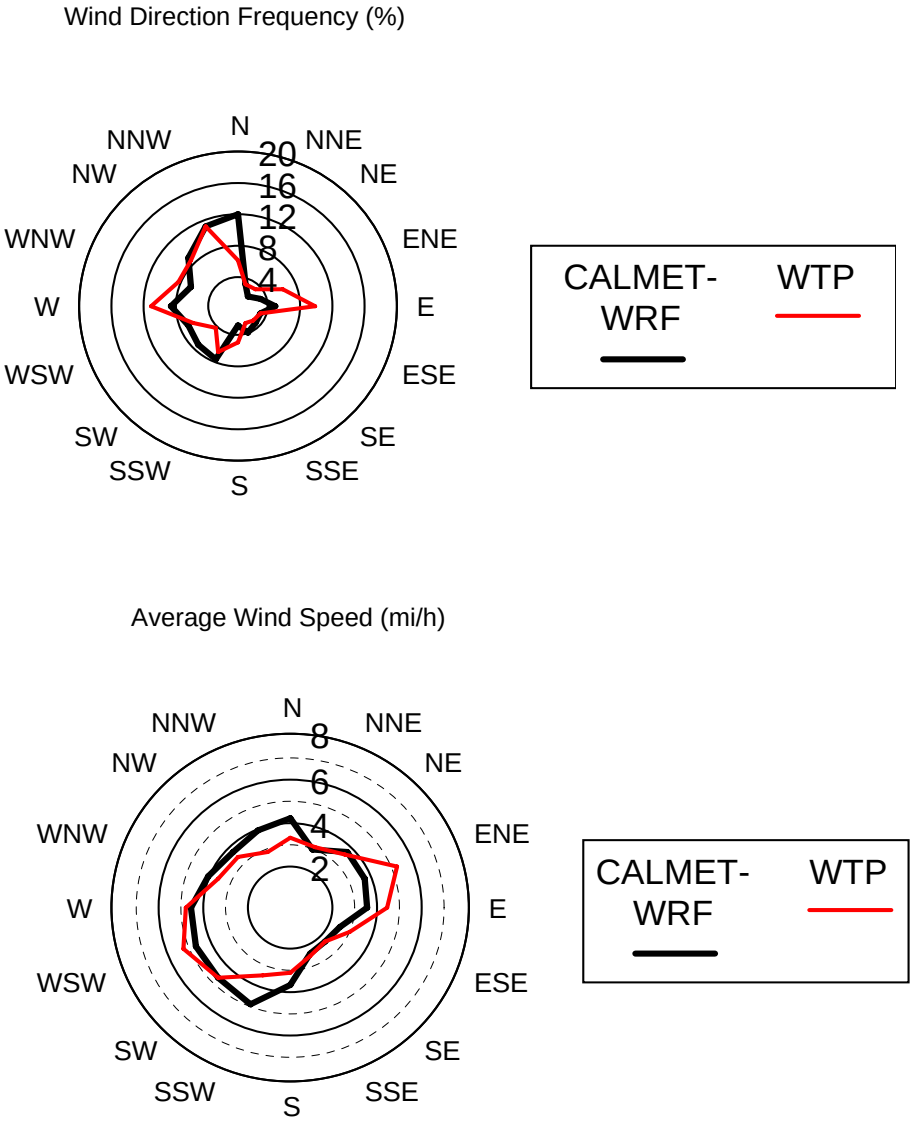


Figure 4.4 CALMET Wind Rose – 2004 – Ministry Monitoring Station 44075



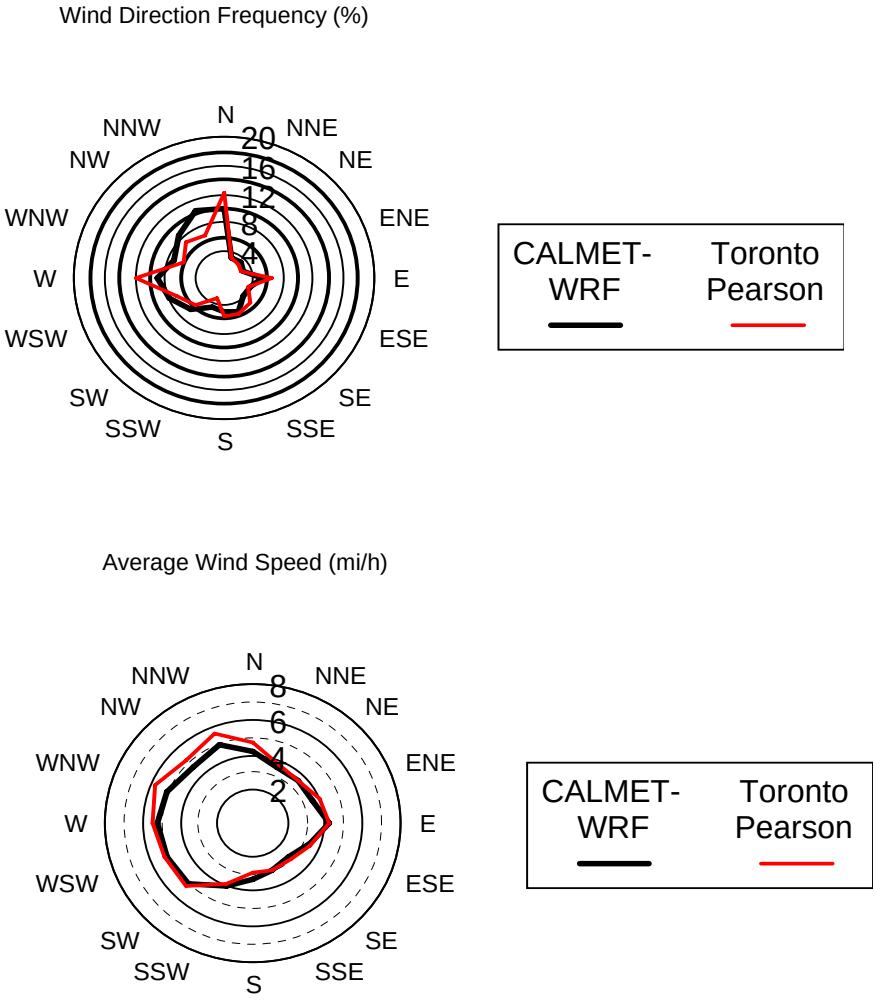
Note: To clarify the information as presented above: the two Wind Roses above for Wind Direction Frequency (%) and Average Wind Speed (mi/h) depict the use of Weather Research and Forecasting (WRF) data (in black) and Ministry Monitoring Station # 44075 data (in red).

Figure 4.5 CALMET Wind Rose – 2004 – Sewage Treatment Plant



Note: To clarify the information as presented above: the two Wind Roses shown for Wind Direction Frequency (%) and Average Wind Speed (mi/h) depict the use of Weather Research and Forecasting (WRF) data (in black) and Ministry Monitoring Station # 44075 data (in red).

Figure 4.6 CALMET Wind Rose – 2004 – Toronto Pearson International Airport



Note: To clarify the information as presented above: the two Wind Roses shown for Wind Direction Frequency (%) and Average Wind Speed (mi/h) depict the use of Weather Research and Forecasting (WRF) data (in black) and Ministry Monitoring Station # 44075 data (in red).

Figure 4.7 CALPUFF Modeling Domain and Receptors Used in the Simulation

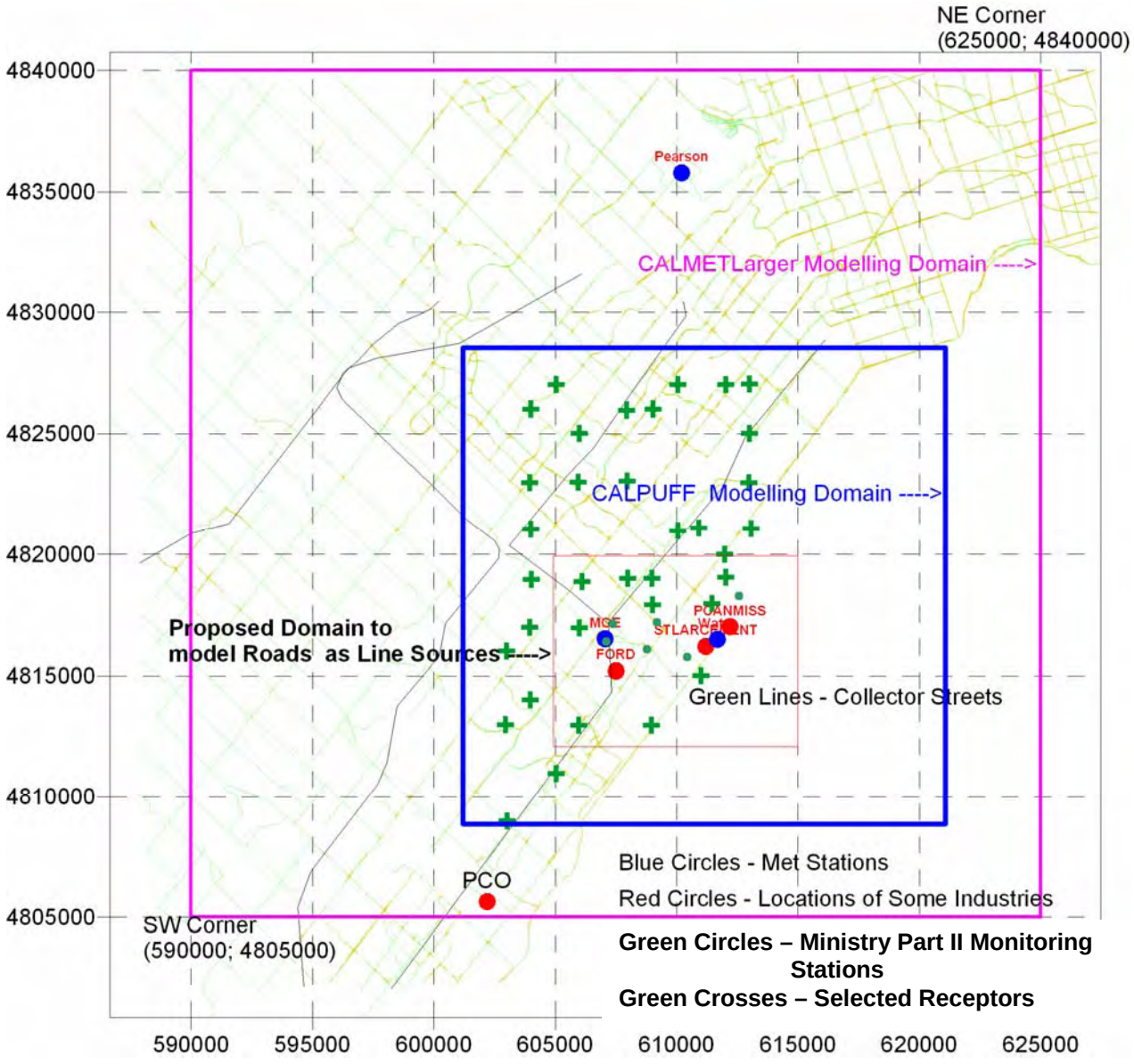
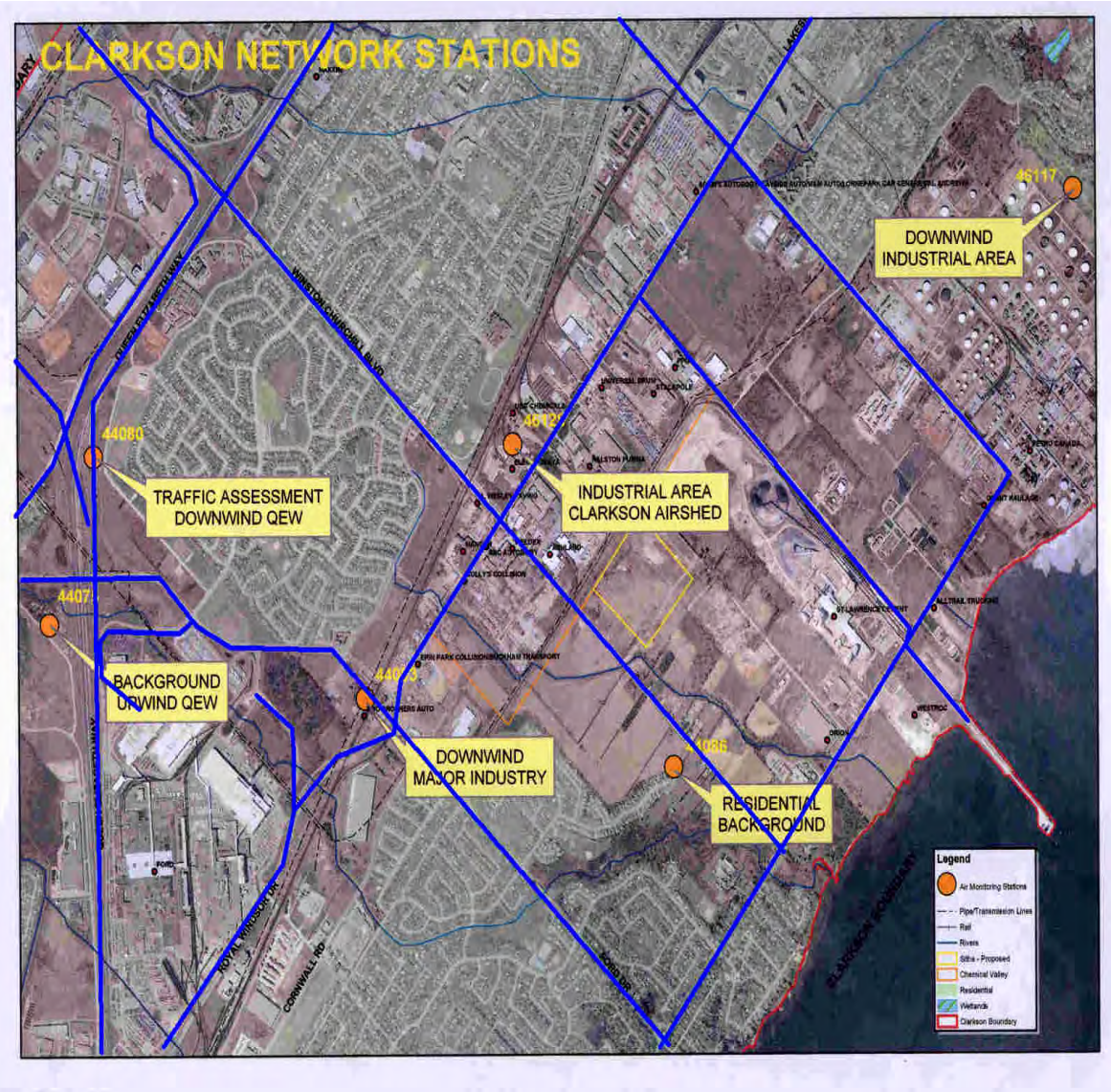


Figure 4.8 Location of Clarkson Airshed Study Area Ambient Air Monitoring Stations – Source Contribution Matrix Receptors



Section - Five

Assessment Results - Clarkson Airshed Study Area

Clarkson Airshed Study: Part III – The Air Quality Dispersion Modeling Source Contribution Assessment

5.0 Introduction

In presenting the results of the Part III Air Quality Dispersion Modelling Source Contribution Assessment, the focus of this Section is two-fold:

(i) First, it presents the predicted contaminant concentrations which were modelled at each of the Clarkson Airshed Part II ambient air monitoring stations and compares them to their respective measured/monitored values for each of the four source sectors.

(ii) Secondly, it presents an Industrial Source Contribution Matrix for 10 individual industry sources that depicts the contaminant concentrations that each industry contributes to predicted and measured values at each of the Ministry monitoring stations.

The Section also presents a discussion of model performance which allows us to draw conclusions on the accuracy of predicted concentrations and the overall success of the model as a key instrument in the assessment.

In reviewing the results presented in this Section, it is important to understand that sources outside of the Clarkson Airshed study area did affect the concentrations measured at the monitoring stations within the airshed. The contributions from outside of the study area modeling domain were from both long-range transport and from other regional sources just outside ("locally derived") of the airshed study area. The contributions from long-range and locally derived sources are discussed in Section 6.0 of this Report.

5.1 Source Sector Contaminant Concentrations

As discussed in Section 3.0 of the Report, the Part III assessment has been organized in such a way as to summarize the contribution that various types of air emission sources have on the air quality in the Clarkson Airshed study area by dividing them into four ”source sectors”, namely:

i. Industrial;
ii. Vehicular;
iii. Residential; and
iv. Miscellaneous.

To that end, the following tables of Section 5.1 outline source contribution concentrations and percent contributions for each contaminant and each source sector. As noted above, the tables also compare predicted or modelled concentrations with the measured values obtained in Part II of the Clarkson Airshed Study.

In reviewing the data presented in this Section it important to acknowledge the following:

(i) All measured data used in the Part III assessment have been taken from the Clarkson Airshed Part II Report for the year 2004 and represent 24 hour annual average and 24 hour 98th percentile concentrations for the key contaminants of concern: PM_{10}, $PM_{2.5}$, NO_x and VOCs.

(ii) The modeled or predicted 24 hour average source sector contaminant concentrations at each Ministry monitoring station are summarized in **Table (a)** for each contaminant. .

(iii) The measured 24 hour average source sector contaminant concentrations at each Ministry monitoring station are then calculated for each source sector using a ratio of the total measured to total predicted value and multiplying this ratio by the predicted source sector value). The measured concentrations are shown in **Table (b)** for each contaminant.

(iv) Using measured 24 hour 98th percentile contaminant concentrations from the Clarkson Airshed Study Part II Report, the measured 98th percentile values at each Ministry monitoring station were calculated for each source sector using a ratio of average source sector value to total average value and multiplying this ratio by the total 98th percentile value. The measured 98th percentile source sector concentrations are summarized in **Table (b)** for each contaminant.

(v) The percent contributions by source sector for each of the Ministry monitoring stations were calculated based on measured/predicted concentrations and summarized in **Table (c)** for each contaminant.

5.1.1 Particulate Matter Less Than or Equal to 10 Microns (PM_{10})

Table 5.1(a) shows the PM_{10} predicted average concentrations at the Ministry ambient air monitoring stations for each of the source sectors.

Table 5.1(b) shows the PM_{10} measured average and 98th percentile concentrations by source sector for each Ministry monitoring station.

Table 5.1(c) shows the PM_{10} measured/predicted percent contribution by source sector for each Ministry monitoring station.

Table 5.1 (a) PM_{10} - Predicted Average Concentrations By Source Sector ($\mu g/m^3$)

Station Number	Total Predicted PM_{10} Avg. Concentrations ($\mu g/m^3$)	PM_{10} Predicted Average Concentrations at Ministry Monitoring Stations ($\mu g/m^3$)			
		Industry	Vehicular	Residential	Miscellaneous
44075	13.43	1.20	11.24	0.81	0.18
44080	28.73	1.25	26.31	0.95	0.22
44083	12.38	3.82	7.31	1.10	0.15
44086	11.05	4.93	4.91	1.09	0.12
46117	5.99	2.46	2.55	0.83	0.15
46128	18.87	3.85	13.83	1.03	0.16

Note: Values shown are annual 24 hr. averages

Table 5.1 (b) PM_{10} - Measured Concentrations By Source Sector ($\mu g/m^3$)

Station Number	Total Measured PM_{10} Concentrations ($\mu g/m^3$)		PM_{10} Measured Concentrations at Ministry Monitoring Stations ($\mu g/m^3$)							
			Industrial		Vehicular		Residential		Miscellaneous	
	Avg	98th %*	Avg	98 %*	Avg	98 %*	Avg	98 %*	Avg	98 %*
44075	18.80	56.10	1.68	5.01	15.74	46.97	1.13	3.37	0.25	0.75
44080	19.60	56.90	0.86	2.50	17.91	51.99	0.66	1.92	0.17	0.49
44083	18.30	52.90	5.66	16.33	10.81	31.25	1.63	4.71	0.21	0.61
44086	15.40	43.70	6.86	19.47	6.83	19.38	1.52	4.34	0.18	0.51
46117	15.40	40.50	6.32	16.63	6.56	17.24	2.13	5.60	0.39	1.03
46128	19.60	53.00	4.00	10.82	14.37	38.86	1.07	2.89	0.16	0.43

Notes: * 98% designates 24 hour 98th percentile concentrations
Values shown are annual 24 hr. averages and annual 24 hr. 98th percentile values

As depicted in **Table 5.1(b) and 5.1(c),** the predominant source sector affecting PM_{10} measured concentrations was Vehicular, except at Stations 44086 and 46117 where both Vehicular and Industrial contributed similar values. These results were as expected particularly at Stations 44075 and 44080 which were located adjacent to the Queen Elizabeth Way (QEW). Stations 46128 and 44083 are also located in proximity to well travelled roadways such as Royal Windsor Dr., Ford Dr. and Winston Churchill Blvd. but reflected a higher industry component due to nearby Ford, Petro Canada Lubricants and the industrial park (vicinity of Royal Windsor Dr. and Winston Churchill Blvd). Stations 44086 and 46117 reflected similar inputs from Industry (St. Lawrence Cement and Petro Canada lubricants, Westroc) and Vehicular (including residential streets). Overall, the Residential sector PM_{10} concentrations are quite low as expected since home heating creates very little, if any PM_{10}.

Table 5.1(c) PM_{10} – Percent Contribution by Source Sector

Source Sector	PM_{10} Emissions by Source Sector (tonnes/ yr)	Average % of Contribution By Source Sector	PM_{10} Measured/Predicted Percent Contribution By Source Sector at Ministry Monitoring Stations					
			44075	44080	44083	44086	46117	46128
Industrial	2370	25	9	4	31	45	41	20
Vehicular	5464	66	84	92	59	44	43	73
Residential	997	8	6	3	9	10	14	6
Miscellaneous	330	1	1	1	1	1	3	1
Total	9161	100	100	100	100	100	100	100
Total Measured PM_{10} Average Concentrations at Ministry Monitoring Stations ($\mu g/m^3$)			**18.80**	**19.60**	**18.30**	**15.40**	**15.40**	**19.00**
Total Measured PM_{10} 98th Percentile Concentrations at Ministry Monitoring Stations ($\mu g/m^3$)			**56.10**	**56.90**	**52.90**	**43.70**	**40.50**	**53.00**

Note: Values shown are annual 24 hr. averages and annual 24 hr. 98th percentile values

Figure 5.1 depicts the PM_{10} measured 98th percentile concentrations at each Part II Ministry ambient air monitoring stations for sources within the airshed.

Figure 5.5 depicts an isopleth of the annual average PM_{10} predicted concentrations which illustrates how the contaminant is distributed throughout the Clarkson Airshed study area.

5.1.2 Particulate Matter Less Than or Equal to 2.5 Microns ($PM_{2.5}$)

Table 5.2(a) shows the $PM_{2.5}$ predicted average concentrations at the Ministry ambient air monitoring stations for each of the source sectors.

Table 5.2(b) shows the $PM_{2.5}$ measured average and 98th percentile concentrations by source sector for each Ministry monitoring station.

Table 5.2 (a) $PM_{2.5}$ - Predicted Average Concentrations By Source Sector ($\mu g/m^3$)

Station Number	Total Predicted PM2.5 Avg. Concentrations ($\mu g/m^3$)	$PM_{2.5}$ Predicted Average Concentrations at Ministry Monitoring Stations ($\mu g/m^3$)			
		Industry	Vehicular	Residential	Miscellaneous
44075	4.68	0.73	3.08	0.85	0.02
44080	9.37	0.76	7.57	1.01	0.03
44083	5.45	2.20	2.08	1.15	0.02
44086	5.36	2.79	1.42	1.14	0.01
46117	3.00	1.30	0.82	0.86	0.02
46128	7.23	2.23	3.90	1.08	0.02

Note: Values shown are annual 24 hr. averages

Table 5.2 (b) $PM_{2.5}$ - Measured Concentrations By Source Sector ($\mu g/m^3$)

Station Number	Total Measured PM2.5 Concentrations ($\mu g/m^3$)		$PM_{2.5}$ Measured Concentrations at Ministry Monitoring Stations ($\mu g/m^3$)							
			Industrial		Vehicular		Residential		Miscellaneous	
	Avg	98th % *	Avg	98 %*	Avg	98 %*	Avg	98 %*	Avg	98 %*
44075	8.00	33.80	1.26	5.28	5.26	22.22	1.45	6.13	0.03	0.13
44080	12.80	43.00	1.04	3.49	10.34	34.74	1.38	4.64	0.04	0.13
44083	10.80	38.00	4.36	15.34	4.12	14.50	2.28	8.02	0.04	0.14
44086	8.70	34.30	4.53	17.86	2.30	9.07	1.85	7.29	0.02	0.08
46117	6.40	28.40	2.78	12.29	1.75	7.77	1.83	8.12	0.04	0.18
46128	11.20	26.30	3.46	8.10	6.04	14.18	1.67	3.92	0.03	0.07

Notes: * 98% designates 24 hour 98th percentile concentrations
Values shown are annual 24 hr. averages and annual 24 hr. 98th percentile values

Table 5.2 (c) $PM_{2.5}$ – Percent Contribution By Source Sector

Source Sector	$PM_{2.5}$ Source Sector Emissions (tonnes/ yr)	Average % of Contribution By Source Sector	$PM_{2.5}$ Measured/Predicted Percent Source Contribution By Source Sector at Ministry Monitoring Stations					
			44075	44080	44083	44086	46117	46128
Industrial	1770	32	16	8	40	52	43	31
Vehicular	1752	49	66	81	38	26	27	54
Residential	994	19	18	11	21	21	29	15
Miscellaneous	38	<1	0	0	0	0	1	0
Total	4554	100	100	100	100	100	100	100
Total Measured $PM_{2.5}$ Average Conc. at Ministry Monitoring Stations ($\mu g/m^3$)			**8.00**	**12.80**	**10.80**	**8.70**	**6.40**	**11.20**
Total Measured $PM_{2.5}$ 98th Percentile Conc. at Ministry Monitoring Stations ($\mu g/m^3$)			**33.80**	**43.00**	**38.00**	**34.30**	**28.40**	**26.30**

Note: Values shown are annual 24 hr. averages and annual 24 hr. 98th percentile values

Table 5.2(c) shows the $PM_{2.5}$ measured/predicted percent contribution by source sector for each Ministry monitoring station.

As depicted in **Table 5.2(b) and 5.2(c)**, the predominant source sectors affecting $PM_{2.5}$ measured concentrations were Vehicular and Industrial. The Vehicular sector was prevalent at Stations 44075, 46128 and 44080 which were located adjacent to the Queen Elizabeth Way (QEW) and major public roadways such as Royal Windsor Dr. and Winston Churchill Blvd. The Industrial sector was consistently higher (albeit not significantly) at Stations 44083, 44086 and 46117 with the industrial park, Ford, Petro Canada Lubricants and St. Lawrence Cement being key contributors. Residential $PM_{2.5}$ concentrations were slightly higher than that for PM_{10} as expected (natural gas heating) and were generally consistent throughout since substantial residential areas exist near each station.

Figure 5.2 depicts the $PM_{2.5}$ measured 98^{th} percentile concentrations at each Part II Ministry ambient air monitoring station for sources within the airshed study area.

Figure 5.6 depicts an isopleth of the annual average $PM_{2.5}$ predicted concentrations which illustrates how the contaminant is distributed throughout the Clarkson Airshed Study Area.

5.1.3 Nitrogen Oxides (NOx)

Table 5.3(a) shows the NO_x average predicted concentrations at the Ministry monitoring stations for each of the source sectors.

Table 5.3(b) shows the NO_x measured average and 98^{th} percentile concentrations by source sector for each Ministry monitoring station.

Table 5.3(c) shows the NO_x measured/predicted percent contribution by source sector for each Ministry monitoring station.

Table 5.3 (a) NO_x – Predicted Average Concentrations By Source Sector ($\mu g/m^3$)

Station Number	Total Predicted NOx Avg. Concentrations ($\mu g/m^3$)	NO_x Predicted Average Concentrations at Ministry Monitoring Stations ($\mu g/m^3$)			
		Industrial	Vehicular	Residential	Miscellaneous
44075	16.31	2.22	13.74	0.35	0.00
44080	36.74	2.21	34.15	0.38	0.00
44083	19.68	6.91	12.31	0.46	0.00
44086	17.84	9.19	8.13	0.52	0.00
46117	8.7	4.79	3.45	0.46	0.00
46128	33.59	6.92	26.21	0.46	0.00

Note: Values shown are annual 24 hr. averages

Table 5.3 (b) NO_x - Measured Concentrations By Source Sector ($\mu g/m^3$)

Station Number	Total Measured NO_x Concentrations ($\mu g/m^3$)		NO_x Measured Concentrations at Ministry Monitoring Stations ($\mu g/m^3$)							
			Industrial		Vehicular		Residential		Miscellaneous	
	Avg	98th % *	Avg	98 %*	Avg	98 %*	Avg	98 %*	Avg	98 %*
44075	53.80	144.99	7.32	19.75	45.33	122.12	1.15	3.12	0.00	0.00
44080	115.30	266.28	6.92	16.03	107.21	247.51	1.17	2.74	0.00	0.00
44083	54.60	166.23	19.17	58.36	34.13	103.98	1.30	3.89	0.00	0.00
44086	45.80	143.86	23.60	74.11	20.88	65.56	1.32	4.19	0.00	0.00
46117	35.30	103.05	19.43	56.72	14.01	40.90	1.86	5.43	0.00	0.00
46128	54.10	157.02	11.15	32.36	42.20	122.48	0.75	2.18	0.00	0.00

Notes: * 98% designates 24 hour 98th percentile concentrations
Values shown are annual 24 hr. averages and annual 24 hr. 98th percentile values

Table 5.3 (c) NOx - Percent Contribution By Source Sector

Source Sector	NO_x Source Sector Emissions (tonnes/ yr)	Average % of Contribution By Source Sector	NO_x Measured/Predicted Percent Contribution By Source Sector at Ministry Monitoring Stations					
			44075	44080	44083	44086	46117	46128
Industrial	15961	31	14	6	35	52	55	21
Vehicular	9848	67	84	93	63	46	40	78
Residential	705	2	2	1	2	3	5	1
Miscellaneous	N/A	0	0	0	0	0	0	0
Total	26514	100	100	100	100	100	100	100
Total Measured NOx Average Concentrations at Ministry Monitoring Stations ($\mu g/m^3$)			**53.80**	**115.30**	**54.60**	**45.80**	**35.30**	**54.10**
Total Measured NOx 98th Percentile Concentrations at Ministry Monitoring Stations ($\mu g/m^3$)			**144.99**	**266.28**	**166.23**	**143.86**	**103.05**	**157.02**

Note: Values shown are annual 24 hr. averages and annual 24 hr. 98th percentile values

As depicted in **Table 5.3(b)**, the predominant source sector affecting NOx measured concentrations was Vehicular, with the exception of Stations 46117 and 44086 where both Vehicular and Industrial contributed similar values with Industrial slightly higher. The dominance of Vehicular was as expected at Stations 44075, 44080, 46128 and to a lesser degree Station 44083, all of which were located adjacent to such public roadways as the Queen Elizabeth Way (QEW), Winston Churchill Blvd., Windsor Dr., and Ford Dr. Stations 44086 and 46117 showed much more of a contribution to NO_x concentrations since they were near such key sources as Ford, Petro Canada and St. Lawrence Cement. Residential Sector NO_x concentrations were somewhat lower than expected but were consistent at each Ministry monitoring station.

Figure 5.3 depicts the NO_x measured 98th percentile concentrations at each Part II Ministry. ambient air monitoring station for sources within the airshed study area.

Figure 5.7 depicts an isopleth of the annual average NO_x predicted concentrations which illustrates how the contaminant is distributed throughout the Clarkson Airshed Study Area.

5.1.4 Volatile Organic Compounds (VOCs)

Table 5.4(a) shows the VOC predicted average concentrations at the Ministry's ambient air monitoring stations for each of the source sectors.

Table 5.4(b) shows the VOC measured average and 98th percentile contaminant concentrations by source sector for each Ministry monitoring station.

Table 5.4(c) shows the VOC measured/predicted percent contribution by source sector for each Ministry monitoring station.

Table 5.4 (a) VOCs – Predicted Average Concentrations By Source Sector (µg/m³)

Station Number	Total Predicted VOC Concentrations (µg/m³)	VOC Predicted Average Concentrations at Ministry Monitoring Stations (µg/m³)			
		Industrial	Vehicular	Residential	Miscellaneous
44075	25.58	5.44	3.45	2.18	14.51
44080	31.18	5.56	7.67	2.37	15.58
44083	29.93	11.61	2.96	2.67	12.69
44086	37.09	20.48	2.20	2.95	11.46
46117	29.47	10.78	1.63	3.00	14.06
46128	41.05	18.89	5.75	2.87	13.54

Note: Values shown are annual 24 hr. averages and annual 24 hr. 98th percentile values

Table 5.4 (b) VOC - Measured Concentrations By Source Sector (µg/m³)

Station Number	Total Measured VOC Concentrations (µg/m³)		VOC Measured Concentrations at Ministry Monitoring Stations (µg/m³)							
			Industrial		Vehicular		Residential		Miscellaneous	
	Avg	98th % *	Avg	98 %	Avg	98 %	Avg	98 %	Avg	98 %
44075	38.03	80.22	8.09	17.06	5.13	10.82	3.24	6.83	21.58	45.50
44080	40.35	86.55	7.20	15.45	9.93	21.30	3.07	6.59	20.16	43.25
44083	44.49	103.16	17.26	40.02	4.40	10.20	3.97	9.20	18.86	43.74
44086	47.92	110.80	26.46	61.18	2.84	6.57	3.81	8.81	14.81	34.24
46117	59.02	150.00	21.59	54.86	3.26	8.29	6.01	15.28	28.16	71.57
46128	64.59	221.10	29.72	101.74	9.05	30.98	4.52	15.47	21.30	72.91

Notes: * 98% designates 24 hour 98th percentile concentrations
Values shown are annual 24 hr. averages and annual 24 hr. 98th percentile values

Table 5.4(c) VOC – Percent Contribution By Source Sector – 2004

Source Sector	VOC Source Sector Emissions (tonnes/ Yr)	Average % of Contribution By Source Sector	VOC Measured/Predicted Percent Source Contribution By Source Sector at Ministry Monitoring Stations					
			44075	44080	44083	44086	46117	46128
Industrial	6505	36	21	18	39	55	37	46
Vehicular	4591	12	14	25	10	6	6	14
Residential	1357	9	9	8	9	8	10	7
Miscellaneous	30832	43	56	50	42	31	48	33
Total	43285	100	100	100	100	100	100	100
Total Measured VOC Average Concentrations at Ministry Monitoring Stations ($\mu g/m^3$)			**38.03**	**40.35**	**44.49**	**47.92**	**59.02**	**64.59**
Total Measured VOC 98th Percentile Concentrations at Ministry Monitoring Stations ($\mu g/m^3$)			**80.22**	**86.55**	**103.20**	**110.80**	**150.00**	**221.10**

Note: Values shown are annual 24 hr. averages and annual 24hr. 98th percentile values

As depicted in **Table 5.4(b) and 5.4(c)**, the predominant source sectors affecting VOC measured concentrations were Industrial and Miscellaneous. With respect to the Industrial sector, these results were as expected particularly at Stations 44086 and 46128 which were located adjacent to and in the vicinity of the nearby industrial park and St. Lawrence Cement. Due to the somewhat extraneous nature of the Miscellaneous Sector (eg. fuel marketing, solvent use etc), VOC concentrations from this sector are generally consistent throughout with the highest value being at Station 46117 (adjacent to Petro Canada lubricants) and the lowest being at Station 44086. The highest Vehicular sector values, although relatively low throughout, were present at Stations 44080 and 46128 which were located adjacent to major roadways (QEW, Royal Windsor Dr., Ford Dr., and Winston Churchill Blvd.). The Residential Sector VOC concentrations were comparable to Vehicular values at most stations and were consistent throughout.

Figure 5.4 depicts both the measured and predicted VOC concentrations at each Part II Ministry ambient air monitoring stations for sources within the airshed.

Figure 5.8 depicts an isopleth of the annual average VOC predicted concentrations which illustrates how the contaminant is distributed throughout the Clarkson Airshed Study Area.

5.1.5 Influence of Emissions from Lakeview Generating Station and Petro-Canada Oakville Refinery

The two most significant air emission sources on either side of the Clarkson Airshed study area have often been thought of as significant factors impacting air quality within the study area. These sources are the Lakeview Generating Station and the Petro Canada, Oakville refinery. Thus, it was of interest as part of this assessment to consider these two specific sources on their own merits as to what their inputs may be.

In this regard, contaminant emissions from the Lakeview Generating Station were already captured in the modelling domain used in this assessment. However, emissions from the Petro Canada Oakville refinery had not been included in the modelling described earlier in this report, since it only operated in January through March of 2004, the year for which detailed modelling was performed. Data for both sources were taken from records of Reg. 127 releases and are included in **Table 5.5**.

Table 5.5 Emission Summary for Lakeview Generating Station and Petro-Canada Oakville Refinery (2004)

Company	Total PM_{10} Tonnes	Total $PM_{2.5}$ Tonnes	Total NO_x Tonnes	Total VOC Tonnes
Lakeview Generating Station	172.72	71.79	3289.94	27.65
Petro Canada Refinery, Oakville	303.19	176.49	456.61	604.97
TOTAL:	**475.91**	**248.28**	**3746.55**	**632.62**

Note: NOx emissions reported as NO.

Based on previous modeling studies conducted by Ministry Environment Monitoring and Reporting Branch (EMRB) staff, the Petro Canada Refinery and Lakeview Generating Station stacks were expected to have minimal contributions to the Clarkson Airshed due basically to their tall stacks and the nature of their source parameters (such as exit gas velocity). The results of the modeling completed as part of this assessment and depicted in **Tables 5.6 and 5.7,** confirm the findings of previous studies depicting both Lakeview and Petro Canada Oakville as contributing <.1% to 6% of all contaminant concentrations measured in the study area with the maximum impact occurring at Station 46117 for $PM_{2.5}$.

Table 5.6 Predicted Annual Average Contaminant Concentrations at Ministry Monitoring Stations - From Lakeview Power Plant (μg/m^3)

Receptors	PM_{10}	$PM_{2.5}$	NO_x	VOC
44075	4.963E-03	2.071E-03	8.577E-02	7.85E-04
44080	5.449E-03	2.271E-03	9.498E-02	8.60E-04
44083	5.255E-03	2.198E-03	9.159E-02	8.38E-04
44086	6.568E-03	2.750E-03	1.163E-01	1.05E-03
46117	8.514E-03	3.570E-03	1.541E-01	1.36E-03
46128	5.449E-03	2.276E-03	9.498E-02	8.65E-04

Table 5.7 Predicted Annual Average Contaminant Concentrations at Ministry Monitoring Stations - From Petro Canada, Oakville (μg/m^3)

Receptors	PM_{10}	$PM_{2.5}$	NO_x	VOC
44075	2.20E-01	1.13E-01	1.03E-01	1.13E-01
44080	2.88E-01	1.48E-01	1.36E-01	1.48E-01
44083	2.48E-01	1.28E-01	1.22E-01	1.28E-01
44086	3.17E-01	1.63E-01	1.64E-01	1.63E-01
46117	7.11E-01	3.62E-01	4.30E-01	3.62E-01
46128	4.35E-01	2.25E-01	2.18E-01	2.25E-01

5.2 Industrial Source Contribution Matrix

The Industrial Source Contribution Matrix is a simple spreadsheet which has been developed based on the contribution of 10 individual industry sources to the predicted and measured concentrations at the Ministry Part II Clarkson Airshed ambient air monitoring stations.[3] The source contributions used in the matrices developed for this assessment are based on 2004 annual average 98th percentile contaminant concentrations.

The Industrial Source Contribution Matrix provides a convenient method for screening the effect of changes to emissions from the specific industrial sources arising as a result of ongoing process optimization and continuing efforts to reduce emissions. It should be noted that these matrices are fundamentally based on the CALPUFF air dispersion modelling carried out for this assessment and hence, strictly apply for changes in emission rates assuming that the fundamental physical parameters that influence dispersion (such as temperature, flow rate, exit velocity, height) are not altered.

It should be noted that the Industrial Source Contribution Matrix approach applies to long-term average or 98th percentile values and may not capture short-term events. The source contributions are

[3] On-site roads (roadways on industrial facilities) were not considered in the source contribution matrix because their contribution to the monitoring stations were small. In addition, the source contribution matrix does not consider the effect of fine particles of sulphates and nitrates which are primarily considered to originate from long range transport. Some further discussion of this latter aspect is provided in Section 6.0 of the report.

likely very different during short-term maximum concentration events, and thus these results should not be used for development of mitigation plans relative to potential impacts that may occur during such events.

In this assessment, the source contribution matrices were developed for each pollutant individually since the CALPUFF model calculates plume depletion for particulate matter and gases differently based on the size of the constituent particles. In addition, the model uses different factors (scavenging rates) to deplete the plume during rainy hours.

In defining the source contribution matrix for each contaminant the following specific approach was taken, using PM_{10} as an example:

(i) The predicted PM_{10} 24 hr. average contaminant concentrations for each industry at each of the Clarkson Airshed Ministry monitoring stations were entered in **Table 5.8(a)**.

(ii) The total predicted PM_{10} 24 hr. average concentrations for the 10 individual industries were summed for each monitoring station and entered in **Table 5.8(a)**.

(iii) Using the predicted PM_{10} 24 hr. average concentrations for each industry as modelled at each monitoring station and the total predicted average value for the 10 industries, a percent contribution for each industry and each monitoring station was calculated and entered in **Table 5.8(a).**

(iv) The ratio of measured to predicted concentrations as depicted in **Table 5.1(b)** is then applied to the total individual industry predicted 24 hr. average PM_{10} concentration for each monitoring station in order to calculate the total individual industry 24 hr. average measured values. Using the measured 24 hr. 98^{th} percentile values from the Clarkson Airshed Study Part II Report, the total measured 24 hr. 98^{th} percentile individual industry concentrations were calculated for each source sector and summarized in **Table 5.8(b)**.

(v) In order to provide ready access to related data [from **Table 5.1(a)**] which are important in understanding the development of the Industry Source Contribution Matrix and in using it for future Clarkson Airshed air quality assessments, **Table 5.8(b)** also includes summaries of:

- the total measured PM_{10} 98th percentile concentrations at each monitoring station, and
- the ratio of measured to predicted average values of PM_{10} for each monitoring station

(vi) The individual industry percentages (which are assumed to be the same for predicted and measured values) were extracted from **Table 5.8(a)** and entered in **Table 5.8(b)**.

(vii) The individual industry measured 98th percentile contaminant concentrations at each of the Ministry monitoring stations were calculated from the percentages and entered in **Table 5.8(b)**.

(viii) The average 98th percentile concentration and average contribution percentage for each individual industry were calculated and entered in **Table 5.8(b).**

In defining the Industrial Source Contribution Matrix for each of the other contaminants (as shown in **Tables 5.9 to 5.11)** the identical approach as noted above for PM_{10} was used.

5.2.1 Particulate Matter Less Than or Equal to 10 Microns (PM_{10})

Table 5.8(a) represents the PM_{10} predicted Industrial Source Contribution Matrix. It shows the predicted average PM_{10} concentration for each individual industry at each Ministry monitoring station and the percent contribution of each industry to the total station concentration.

Table 5.8 (a) Industrial Source Contribution Matrix – PM_{10} Predicted Average Concentrations (µg/m^3)

Individual Industries	Emission (tonne/ yr)	Industry Source Contribution to PM_{10} Predicted Concentrations at Monitoring Stations											
		44075		44080		44083		44086		46117		46128	
		%	µg/ m^3	%	µg/ m^3	%	µg/ m^3	%	µg/ m^3	%	µg/ m^3	%	µg/ m^3
1 – Westroc Inc.	1	0	0.00	0	0.00	0	0.00	0	0.00	1	<0.01	0	0.00
2 – Universal Drum	1	2	<0.01	2	<0.01	1	<0.01	1	0.01	1	<0.01	5	0.03
3 – PPG Canada Inc	-	-	-	-	-	-	-	-	-	-	-	-	-
4 – Ashland Chemical	-	-	-	-	-	-	-	-	-	-	-	-	-
5 – Ford	39	21	0.04	13	0.04	19	0.08	3	0.03	3	0.01	6	0.04
6 – Orion Bus Ind.	1	1	<0.01	0	0.00	1	<0.01	2	0.02	1	<0.01	0	0.00
7 – Petro Canada Lub.	74	6	0.01	8	0.03	4	0.02	2	0.02	12	0.05	5	0.03
8 – St. Lawrence Cement	68	63	0.13	66	0.20	69	0.28	80	0.71	73	0.30	67	0.40
9 – Stackpole Limited	15	7	0.02	10	0.03	6	0.02	11	0.10	9	0.04	16	0.10
10 – Royal Ready Mix	1	0	0.00	1	<0.01	0	0.00	1	0.01	0	0.00	1	<0.01
Total Predicted PM_{10} Individual Industry Average Conc. at Monitoring Sta. (µg/m^3)		**0.20**		**0.30**		**0.40**		**0.90**		**0.40**		**0.60**	
Total Predicted PM_{10} Average Conc. At Monitoring Sta. (µg/m^3)		**13.43**		**28.73**		**12.38**		**11.05**		**5.99**		**18.87**	

Notes: Values depicted as – for PPG and Ashland indicate NPRI releases were BT (below threshold: 0.5 tonnes/year) in 2004 and were not reported
Values shown are annual 24 hr. averages

Table 5.8 (b) Industrial Source Contribution Matrix - PM_{10} Measured 98th Percentile Concentrations (µg/m³)

Individual Industries	Overall Contribution of Industries		Industry Source Contribution to PM_{10} 98th Percentile Measured Concentrations at Monitoring Stations											
			44075		44080		44083		44086		46117		46128	
	Avg %	Avg Conc.	%	µg/m³	%	µg/m³	%	µg/m³	%	µg/m³	%	µg/m³	%	µg/m³
1 – Westroc Inc.	<1	0.00	0	0.00	0	.000	0	0.00	0	0.00	1	0.03	0	0.00
2 – Universal Drum	2	0.04	2	0.02	2	0.01	1	0.02	1	0.04	1	0.03	5	0.09
3 – PPG Canada Inc	-	-	-	-	-	-	-	-	-	-	-	-	-	
4 – Ashland Chemical	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5 – Ford	11	0.15	21	0.18	13	0.08	19	0.33	3	0.11	3	0.08	6	0.10
6 – Orion Bus Ind.	1	0.02	1	0.01	0	0.00	1	0.02	2	0.07	1	0.03	0	0.00
7 – Petro Canada Lub.	6	0.11	6	0.05	8	0.05	4	0.07	2	0.07	12	0.33	5	0.09
8 – St. Lawrence Cement	69	1.33	63	0.52	64	0.38	69	1.17	80	2.84	73	1.97	67	1.12
9 – Stackpole Limited	10	0.19	7	0.06	10	0.06	6	0.10	11	0.39	9	0.24	16	0.27
10 – Royal Ready Mix	1	0.01	0	0.00	1	0.01	0	0.00	1	0.04	0	0.00	1	0.02
Total Measured PM_{10} Individual Industry 98th Percentile Conc. at Monitoring Sta. (µg/m³)			**0.84**		**0.59**		**1.71**		**3.56**		**2.71**		**1.69**	
Total Measured PM_{10} 98th Percentile Conc. at Monitoring Sta. (µg/m³)			**56.10**		**56.90**		**52.90**		**43.70**		**40.50**		**53.00**	

Notes: Values depicted as – for PPG and Ashland indicate NPRI releases were BT (below threshold: 0.5 tonnes/yr) in 2004 and were not reported
Values shown are annual 24 hr. 98th percentile values

The table also includes the total predicted PM_{10} average individual industry concentrations for each monitoring station, the total predicted average PM_{10} concentration for monitoring station and the emissions in tonnes/yr for each industry.

Table 5.8(b) represents the PM_{10} measured Industrial Source Contribution Matrix. It shows the measured PM_{10} 98th percentile concentration for each individual industry at each Ministry monitoring station and the percent contribution of each industry to the total station concentration.

The table also includes the total measured 98th percentile PM_{10} individual industry concentrations for each monitoring station, the overall average 98th percentile PM_{10} concentration for each industry, the average percent contribution of each industry to the total station concentration and the total measured 98th percentile PM_{10} concentration at each monitoring station.

The highest measured PM_{10} 98th percentile concentration of 2.84 µg/m³ occurred at station 44086. This concentration is 80% of the total PM_{10} measured at the monitoring station and is attributable to St. Lawrence Cement. The second highest PM_{10} 98th percentile concentration of 1.97 µg/m³ occurred at station 46117, was 73 % of the total PM_{10} measured at the monitoring station and was also attributed to St. Lawrence Cement operations.

5.2.2 Particulate Matter Less Than or Equal to 2.5 Microns ($PM_{2.5}$)

Table 5.9(a) represents the $PM_{2.5}$ predicted Industrial Source Contribution Matrix. It shows the predicted average $PM_{2.5}$ concentration for each individual industry at each Ministry monitoring station and the percent contribution of each industry to the total station concentration.

The table also includes the total predicted $PM_{2.5}$ individual industry average concentrations for each monitoring station, the total predicted average $PM_{2.5}$ concentration for each monitoring station and the emissions in tonnes/yr for each industry.

Table 5.9(b) represents the $PM_{2.5}$ measured Industrial Source Contribution Matrix. It shows the measured $PM_{2.5}$ 98th percentile concentration for each individual industry at each Ministry monitoring station and the percent contribution of each industry to the total station concentration.

The table also includes the total measured 98th percentile $PM_{2.5}$ individual industry concentrations for each monitoring station, the overall average $PM_{2.5}$ concentration for each industry, the average percent

Table 5.9 (a) Industrial Source Contribution Matrix - Predicted $PM_{2.5}$ Average Concentrations (µg/m^3)

Individual Industries	Emission (tonne/ yr)	Industry Source Contribution to Predicted $PM_{2.5}$ Average Concentrations at Ministry Monitoring Stations											
		44075		44080		44083		44086		46117		46128	
		%	µg/ m^3	%	µg/ m^3	%	µg/ m^3	%	µg/ m^3	%	µg/ m^3	%	µg/ m^3
1 – Westroc Inc.	1	1	<0.01	1	<0.01	1	<0.01	1	<0.01	1	<0.01	1	<0.01
2 – Universal Drum	<1	1	<0.01	2	<0.01	1	<0.01	1	<0.01	1	<0.01	4	0.01
3 – PPG Canada Inc	-	-	-	-	-	-	-	-	-	-	-	-	-
4 – Ashland Chemical	-	-	-	-	-	-	-	-	-	-	-	-	-
5 – Ford	8	26	0.03	14	0.02	20	0.04	3	0.01	2	0.01	6	0.01
6 – Orion Bus Ind.	<1	1	<0.01	1	<0.01	1	<0.01	2	<0.01	1	<0.01	0	0.00
7 – Petro Canada Lub.	55	11	0.01	1	0.01	8	0.02	5	0.02	20	0.04	9	0.02
8 – St. Lawrence Cement	34	52	0.05	57	0.06	61	0.12	73	0.22	64	0.13	58	0.12
9 – Stackpole Limited	7	8	0.01	12	0.01	8	0.02	15	0.05	11	0.02	21	0.04
10 – Royal Ready Mix	<1	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	<0.01
Total Predicted Average $PM_{2.5}$ Individual Industry Conc. at Monitoring Sta. (µg/m^3)		**0.10**		**0.10**		**0.20**		**0.30**		**0.20**		**0.20**	
Total Predicted Average PM2.5 Conc. at Monitoring Sta. (µg/m^3)		**4.68**		**9.37**		**5.45**		**5.36**		**3.00**		**7.23**	

Note: Values depicted as – for PPG and Ashland indicate NPRI releases were BT (below threshold: 0.3 tonnes/yr) in 2004 and were not reported
Values shown are annual 24 hr. averages

contribution of each industry to the total station concentration and the total measured 98th percentile $PM_{2.5}$ concentration at each monitoring station.

Table 5.9 (b) Industrial Source Contribution Matrix - $PM_{2.5}$ Measured 98th Percentile Concentrations µg/m³)

Individual Industries	Overall Contribution Of Industries		Industry Source Contribution to PM2.5 98th Percentile Measured Concentrations at Ministry Monitoring Stations											
			44075		44080		44083		44086		46117		46128	
	Avg %	Avg Conc.	%	µg/m³	%	µg/m³	%	µg/m³	%	µg/m³	%	µg/m³	%	µg/m³
1 – Westroc Inc.	1	0.01	1	0.01	2	<0.01	1	0.01	1	0.02	1	0.02	1	0.01
2 – Universal Drum	<2	0.02	1	0.01	2	<0.01	1	0.01	1	0.02	1	0.02	4	0.03
3 – PPG Canada Inc	-	-	-	-	-		-	-	-		-	-	-	-
4 – Ashland Chemical	-	-	-	-	-		-	-	-		-	-	-	-
5 – Ford	12	0.12	26	0.19	20	0.09	20	0.29	3	0.06	2	0.04	6	0.04
6 – Orion Bus Ind.	1	0.02	1	0.01	3	0.01	1	0.01	2	0.04	1	0.02	0	0.00
7 – Petro Canada Lub.	11	0.12	11	0.07	3	0.01	8	0.11	5	0.10	20	0.38	9	0.07
8 – St. Lawrence Cement	61	0.76	52	0.37	60	0.29	61	0.86	73	1.41	64	1.23	58	0.42
9 – Stackpole Limited	13	0.15	8	0.06	10	0.06	8	0.11	15	0.28	11	0.21	21	0.15
10 – Royal Ready Mix	<1	<0.01	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	0.01
Total Meas. $PM_{2.5}$ Individual Industry 98th Percentile Conc. at Monitoring Sta. [µg/m³]			**0.72**		**0.46**		**1.40**		**1.93**		**1.92**		**0.73**	
Total Measured PM2.5 98th Percentile Conc. At Monitoring Sta. (µg/m³)			**33.80**		**43.00**		**38.00**		**34.30**		**28.40**		**26.30**	

Note: Values depicted as – for PPG and Ashland indicate NPRI releases were BT (below threshold: 0.3 tonnes/yr) in 2004 and were not reported
Values shown are annual 24 hr. 98th percentile values

The highest individual industry measured $PM_{2.5}$ 98th percentile concentration of 1.41 µg/m³ occurred at Station 44086 and represented 73% of the total $PM_{2.5}$ measured 98th percentile concentration at the Station. This value was attributed to St. Lawrence Cement. The second highest $PM_{2.5}$ 98th percentile value of 1.23 µg/m³ occurred at station 46117 and represented 64 % of the total measured. This value was also attributed to St. Lawrence Cement operations.

5.2.3 Nitrogen Oxides (NO_x)

Table 5.10(a) represents the NO_x predicted Industrial Source Contribution Matrix. It shows the predicted average NO_x concentration for each individual industry at each Ministry monitoring station and the percent contribution of each industry to the total station concentration.

The table also includes the total predicted NO_x individual industry average concentrations for each monitoring station, the total predicted average NO_x concentration for monitoring site and emissions in tonnes/yr for each industry.

Table 5.10 (a) Industrial Source Contribution Matrix – NO_x Predicted Concentrations (µg/m^3)

Individual Industries	Emission (tonne/ yr)	Industry Source Contribution to NO_x Predicted Concentrations at Ministry Monitoring Stations											
		44075		44080		44083		44086		46117		46128	
		%	µg/ m3	%	µg/ m3	%	µg/ m3	%	µg/ m3	%	µg/ m3	%	µg/ m3
1 – Westroc Inc.	-	-	-	-	-	-	-	-	-	-	-	-	-
2 – Universal Drum	-	-	-	-	-	-	-	-	-	-	-	-	-
3 – PPG Canada Inc	3	0	0.00	0	0.00	0	0.00	2	0.02	1	0.01	2	0.02
4 – Ashland Chemical	-	-	-	-	-	-	-	-	-	-	-	-	-
5 – Ford	52	1	0.02	9	0.11	11	0.25	9	0.08	4	0.03	8	0.10
6 – Orion Bus Ind.	-	-	-	-	-	-	-	-	-	-	-	-	-
7 – Petro Canada Lub.	484	6	0.13	12	0.14	5	0.12	17	0.15	60	0.42	18	0.22
8 – St. Lawrence Cement	1470	93	2.05	79	0.95	84	1.93	72	0.65	35	0.24	72	0.86
9 – Stackpole Limited	-	-		-	-	-	-	-	-	-	-	-	-
10 – Royal Ready Mix	0	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Total Predicted Average $PM_{2.5}$ Individual Industry Conc. at Monitoring Sta. (µg/m^3)		**2.20**		**1.20**		**2.30**		**0.90**		**0.70**		**1.20**	
Total Predicted Average PM2.5 Conc. at Monitoring Sta. (µg/m^3)		**16.31**		**36.74**		**19.68**		**17.84**		**8.70**		**33.59**	

Note: Values depicted as "– "indicate NPRI releases were BT (below threshold: 20 tonnes/yr) in 2004 and were not reported. NOx predicted values from Calpuff are equivalent to NO_2

Table 5.10(b) represents the NO_x measured Industrial Source Contribution Matrix. It shows the measured NO_x 98th percentile concentration for each individual industry at each Ministry monitoring station and the percent contribution of each industry to the total station concentration.

The table also includes the total measured 98th percentile NO_x individual industry concentrations for each monitoring station, the overall average NO_x 98th percentile concentration for each industry, the average percent contribution of each industry to the total station concentration and the total measured 98th percentile NO_x concentration at each monitoring station.

The highest measured individual industry NO_x concentration of 18.19 µg/m^3 occurred at Station 44075, was attributed to St. Lawrence Cement and represented 93% of the total NO_x measured at the Station. The second highest NO_x value of 16.32 µg/m^3 occurred at station 44083, was attributed to St. Lawrence Cement and represented 84 % of the total measured at 44083.

Table 5.10 (b) Industrial Source Contribution Matrix – NO_x 98th Percentile Measured Concentrations (µg/m³)

Individual Industries	Overall Contribution of Industries		Industry Source Contribution to NOx 98th Percentile Measured Concentrations at Ministry Monitoring Stations											
			44075		44080		44083		44086		46117		46128	
	Avg %	Avg Conc.	%	µg/m³	%	µg/m³	%	µg/m³	%	µg/m³	%	µg/m³	%	µg/m³
1 – Westroc Inc.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2 – Universal Drum	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3 – PPG Canada Inc	<1	0.02	0	0.00	0	0.00	0	0.00	2	0.15	1	0.08	2	0.11
4 – Ashland Chemical	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5 – Ford	7	0.27	1	0.20	9	0.78	11	2.14	9	0.65	4	0.34	8	0.45
6 – Orion Bus Ind.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7 – Petro Canada Lub.	20	0.60	6	1.17	12	1.04	5	0.97	17	1.23	60	4.98	18	1.01
8 – St. Lawrence Cement	72	3.07	93	18.19	79	6.88	84	16.32	72	5.23	35	2.91	72	4.04
9 – Stackpole Limited	0	0.00	0	0.00	-	-	-	-	-	-	-	-	-	
10 – Royal Ready Mix	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Total Measured 98th Percentile NO_x Individual Industry Conc. at Monitoring Stations [µg/m³]			**19.56**		**8.70**		**19.43**		**7.26**		**8.31**		**5.61**	
Total Measured NO_x 98th Percentile Conc. at Monitoring Stations (µg/m³)			**144.99**		**266.28**		**166.23**		**143.86**		**103.05**		**157.02**	

Note: Values depicted as "–" indicate NPRI releases were BT (below threshold: 20 tonnes/yr) in 2004 and were not reported.
NOx measured values includes NO and NO_2.
Values shown are annual 24 hr. 98th percentile values

5.2.4 Volatile Organic Compounds (VOCs)

Table 5.11(a) represents the VOC predicted Industrial Source Contribution Matrix. It shows the predicted average VOC concentration for each individual industry at each Ministry Part II ambient air monitoring station and the percent contribution of each industry to the total station concentration.

The table also includes the total predicted average VOC individual industry concentrations for each monitoring station, the total predicted average VOC concentration for each monitoring station and the emissions in tonnes/yr.

Table 5.11 (a) Industrial Source Contribution Matrix - VOC Average Predicted Concentrations (µg/m^3)

Individual Industries	Emission (tonne/ yr)	Industry Source Contribution to VOC Average Predicted Concentrations at Ministry Monitoring Stations											
		44075		44080		44083		44086		46117		46128	
		%	µg/ m3	%	µg/ m3	%	µg/ m3	%	µg/ m3	%	µg/ m3	%	µg/ m3
1 – Westroc Inc.	23	1	0.03	1	0.02	1	0.04	2	0.08	1	0.05	1	0.06
2 – Universal Drum	120	10	0.28	18	0.41	13	0.45	19	0.82	5	0.24	45	2.66
3 – PPG Canada Inc	100	3	0.08	7	0.16	5	0.17	14	0.60	5	0.25	10	0.59
4 – Ashland Chemical	18	2	0.06	2	0.04	3	0.11	6	0.26	1	0.05	6	0.35
5 – Ford	709	64	1.79	40	0.93	54	1.89	15	0.65	5	0.24	15	0.88
6 – Orion Bus Ind.	73	2	0.06	2	0.04	4	0.14	20	0.86	3	0.15	2	0.12
7 – Petro Canada Lub.	198	18	0.50	29	0.68	19	0.66	23	.099	80	3.92	20	1.18
8 – St. Lawrence Cement	36	<1	<0.03	<1	<0.02	<1	<0.04	<1	<0.04	<1	<0.05	<1	<0.06
9 – Stackpole Limited	12	<1	<0.03	1	0.02	1	0.04	1	0.04	<1	<0.05	1	0.06
10 – Royal Ready Mix	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Predicted Average VOC Individual Industry Concentrations at Monitoring Stations (µg/m^3)		**2.80**		**2.30**		**3.50**		**4.30**		**4.90**		**5.90**	
Total Predicted Average VOC Concentrations at Monitoring Stations (µg/m^3)		**25.58**		**31.18**		**29.93**		**37.09**		**29.47**		**41.05**	

Notes: Values depicted as -. for Royal Ready Mix indicate NPRI releases were BT (below threshold: 10 tonnes/yr) in 2004 and were not reported

Values shown are annual 24 hr. averages

Table 5.11(b) represents the VOC measured Industrial Source Contribution Matrix. It shows the measured VOC 98th percentile concentration for each individual industry at each Ministry monitoring station and the percent contribution of each industry to the total station concentration.

The table also includes the total measured 98th percentile VOC individual industry concentrations for each monitoring station, the overall average VOC 98th percentile concentration for each industry, the average percent contribution of each industry to the total station concentration and the total measured 98th percentile VOC concentration at each monitoring station.

The highest measured individual industry VOC 98th percentile concentration of 19.96 µg/m^3 occurred at Station 46117, was attributed to Petro Canada lubricants. The value represented 80% of the total concentration measure at Station 46117. The second highest VOC concentration of 14.30 µg/m^3 occurred at station 46128 and was attributed to Universal Drum. This value represented 45% of the total measured at the Station.

Table 5.11 (b) Industrial Source Contribution Matrix – VOC Measured 98th Percentile Concentrations (µg/m³)

Individual Industries	Overall Contribution of Industries		Industry Source Contribution to Measured VOC Concentrations at Ministry Monitoring Stations											
			44075		44080		44083		44086		46117		46128	
	Avg %	Avg Conc.	%	µg/m³	%	µg/m³	%	µg/m³	%	µg/m³	%	µg/m³	%	µg/m³
1 – Westroc Inc.	1	0.07	1	0.09	1	0.06	1	0.12	2	0.26	1	0.25	1	0.32
2 – Universal Drum	18	1.23	10	0.88	18	1.15	13	1.57	19	2.44	5	1.25	45	14.30
3 – PPG Canada Inc	7	0.46	3	0.26	7	0.45	5	0.60	14	1.80	5	1.25	10	3.18
4 – Ashland Chemical	3	0.42	2	0.18	2	0.13	3	0.36	6	0.77	1	0.25	6	1.91
5 – Ford	32	1.57	64	5.61	40	2.55	54	6.52	15	1.93	5	1.25	15	4.78
6 – Orion Bus Ind.	6	0.32	2	0.18	2	0.13	4	0.48	20	2.57	3	0.75	2	0.64
7 – Petro Canada Lub.	31	2.27	18	1.58	29	1.85	19	2.29	23	2.96	80	19.96	20	6.37
8 – St. Lawrence Cement	<1	<0.06	<1	<0.09	<1	<0.06	<1	<0.12	<1	<0.13	<1	<0.25	<1	<0.32
9 – Stackpole Limited	<1	.054	<1	<0.09	1	0.06	1	0.12	1	0.13	<1	<0.25	1	0.32
10 – Royal Ready Mix	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Meas. 98th Percentile VOC Individual Industry Conc. at Monitoring Stations [µg/m³]			**8.78**		**6.38**		**12.07**		**12.86**		**24.94**		**31.78**	
Total Measured 98th Percentile VOC Conc. at Monitoring Stations (µg/m³)			**80.22**		**86.55**		**103.16**		**110.80**		**150.00**		**221.10**	

Note: Values depicted as – for Royal Ready Mix indicate NPRI releases were BT (below threshold: 10 tonnes/yr) in 2004 and were not reported.
Values shown are annual 24 hr. 98th percentile values.

5.3 Evaluation of CALPUFF Model Performance

The overall performance of the CALMET/CALPUFF air modelling system in applying it to emission sources within the Clarkson Airshed study area, was investigated using two approaches. The basic approach was to evaluate model performance based on the fractional bias of the predictions, following an EPA methodology (U.S. EPA, 1992). In addition, an alternative approach, also based on EPA methods (EPA, 1998), involving the use of Q-Q plots[4], was also used to investigate the "reasonableness" of the predictions provided by the model.

5.3.1 Bias Plots

The EPA's fractional bias approach was selected as one measure of performance in this evaluation because it has two desirable features (U.S. EPA, 1992). These features are::

[4] Q-Q plots are ranked pairings of predicted and observed concentrations (not paired in time), such that any given quantile of predicted concentration is plotted versus the same quantile of the observed concentrations. (EPA, 2006).

(i) First, it is symmetrical and depicts bounded values that range between -2.0 (extreme under prediction) and +2.0 (extreme over prediction).

(ii) Second, the fractional bias is a dimensionless number, which is convenient for comparing the results from studies involving different concentration levels or even different pollutants.

The general expression for the fractional bias (FB) is given by:

$$FB = 2\left(\frac{PR - OB}{PR + OB}\right)$$

The fractional bias of the average is computed using this equation where OB and PR refer to the averages of the observed (OB) and predicted (PR) highest 25 values. The same expression is used to calculate the fractional bias of the standard deviation where OB refers to the standard deviation of the 25 highest observed values and PR refers to the standard deviation of the 25 highest predicted values.

Figures 5.9 and 5.10 are fractional bias plots for the maximum 24 hour and annual average results in which the fractional bias of the standard deviation (y-axis) is plotted against the fractional bias of the average (x-axis). Typically, higher correlation is obtained when longer averaging periods are compared and for this reason the maximum 24-hour and annual average were used in this assessment as indicators of this correlation. Model predictions that plot close to the centre of the graph (0, 0) are relatively free from bias, while model predictions that plot further away from the centre tend to over predict or under predict. Values of the fractional bias that are equal to +0.67 are equivalent to an over prediction by a factor of two, while values that are equal to -0.67 are equivalent to an under prediction by a factor of two.

Fractional bias values within a factor of two (2) are considered as demonstrating that the predicted values determined by the model do provide reasonable agreement, on the average, with measured values.

5.3.2 Q-Q Plots

$PM_{2.5}$ Q-Q plots are also used to provide diagnostic as well as descriptive information about model performance (EPA, 2006). The Q-Q plots method is an effective approach for comparing the frequency distribution of two data sets.

Based on the measured and predicted 24 hour $PM_{2.5}$ concentrations the Q-Q plots were developed for each of the three monitoring stations 44075, 44086 and 46117 at which a TEOM continuous monitor was used. A solid green line is indicative of perfect agreement, and two black lines indicate a factor of two (under or over prediction).

As in the case of the fractional bias approach outlined in Section 5.3.1, Q-Q plots that depict values within a factor of two (2) are considered as demonstrating that the predicted values determined by the model do provide reasonable agreement, on the average, with measured values.

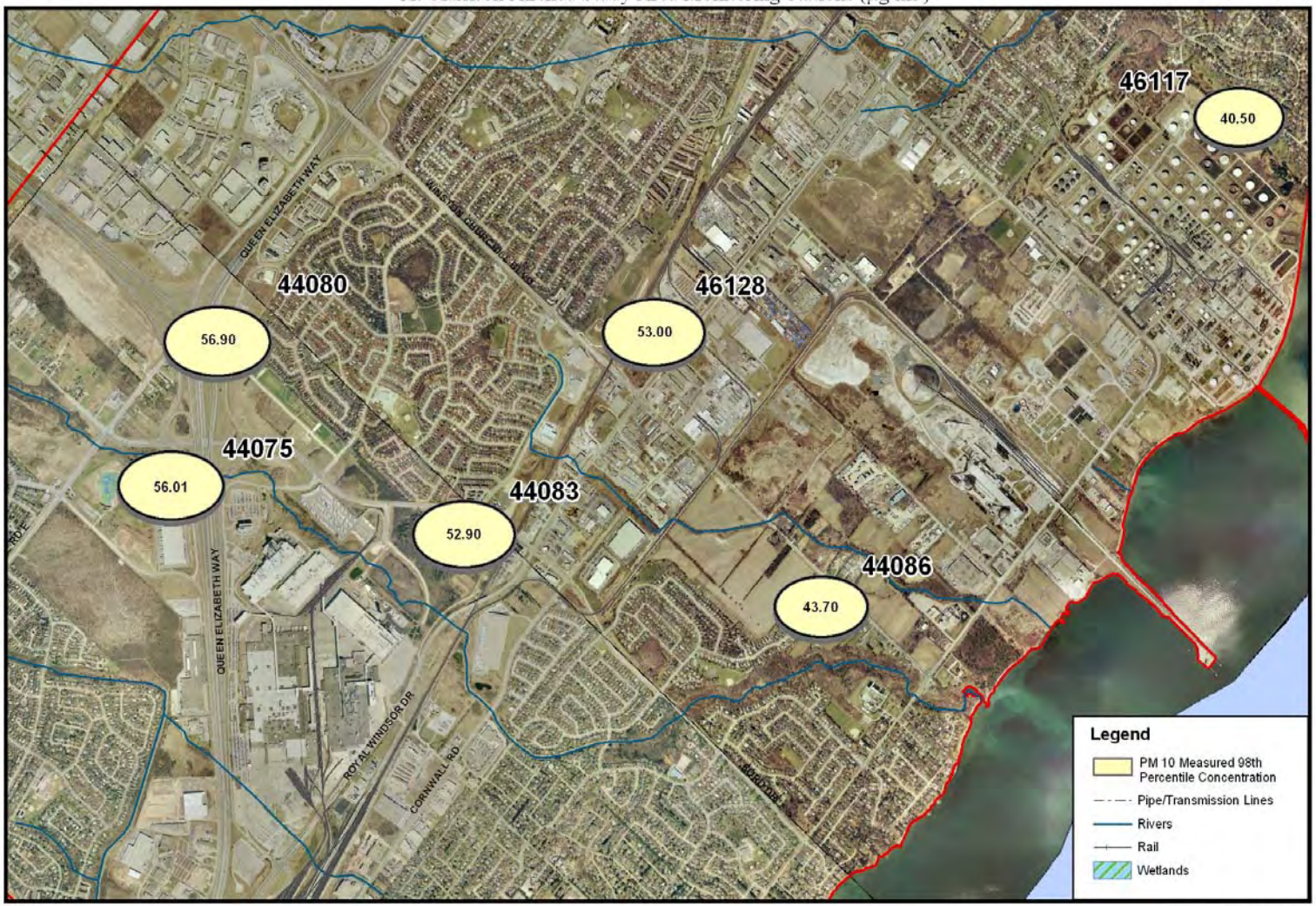
Figure 5.11 presents Q - Q Plots for $PM_{2.5}$ 24 hour average concentrations. Based on **Figure 5.11** it is clear that majority of data for all three TEOM stations are within the factor of 2. The best performance is shown for station 44075 (background monitoring station), which suggests that the overall contributions from within and outside of the Clarkson Airshed study area are reasonably reflected in the analysis. The residential background Station 44086 and downwind industrial Station 46117 are thought to be impacted more by local industry and residential fuel burning.

Figure 5.12 represents Q-Q Plots for NO_x, on a 24-hour average basis. In this case, all 6 stations are presented on the same graph. This graph demonstrates once again, that model performance is reasonable. The flattening of the curves at the lower concentrations arises from the assumption that background is constant when in reality, background will change over time as the result of air flow carrying contamination into the Clarkson Airshed study area.

Ontario

Figure 5.1 - PM 10 Measured 98th Percentile Concentrations
At Clarkson Airshed Study Area Monitoring Stations (µg/m3)

Ministry of the Environment



Projection
Universal Transverse Mercator
Zone 17
False Easting: 500000m
False Northing: 0m
Central Meridian: -81
Scale Factor: 0.9996
Latitude of Origin: 0
1983 North American Datum

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Published February 2008
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Printed in Ontario, Canada

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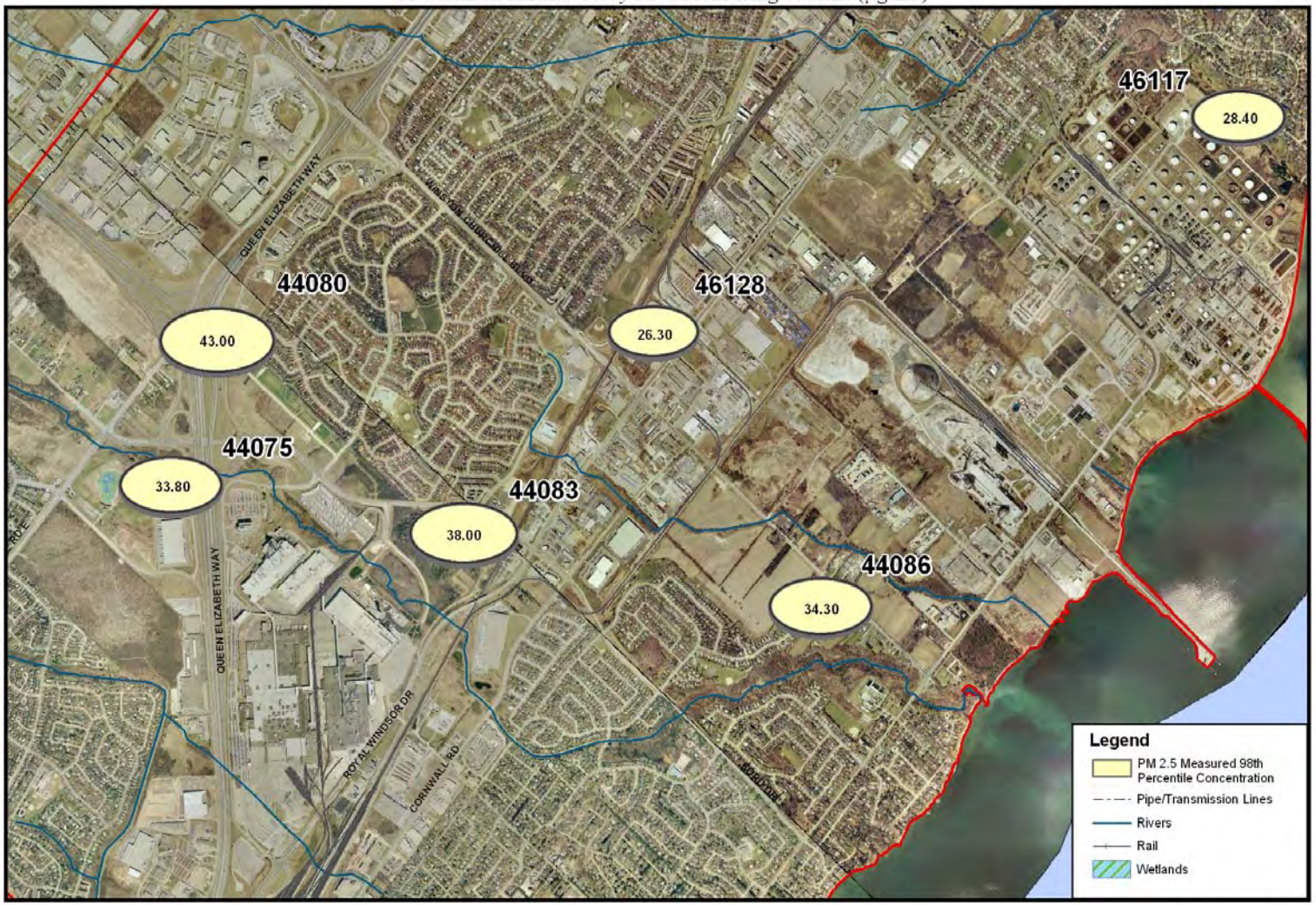
Figure 5.2 - PM 2.5 Measured 98th Percentile Concentrations
At Clarkson Airshed Study Area Monitoring Stations (µg/m3)

Ministry of the Environment



Projection
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Central Meridian: -81
Scale Factor: 0.9996
Latitude of Origin: 0
1983 North American Datum

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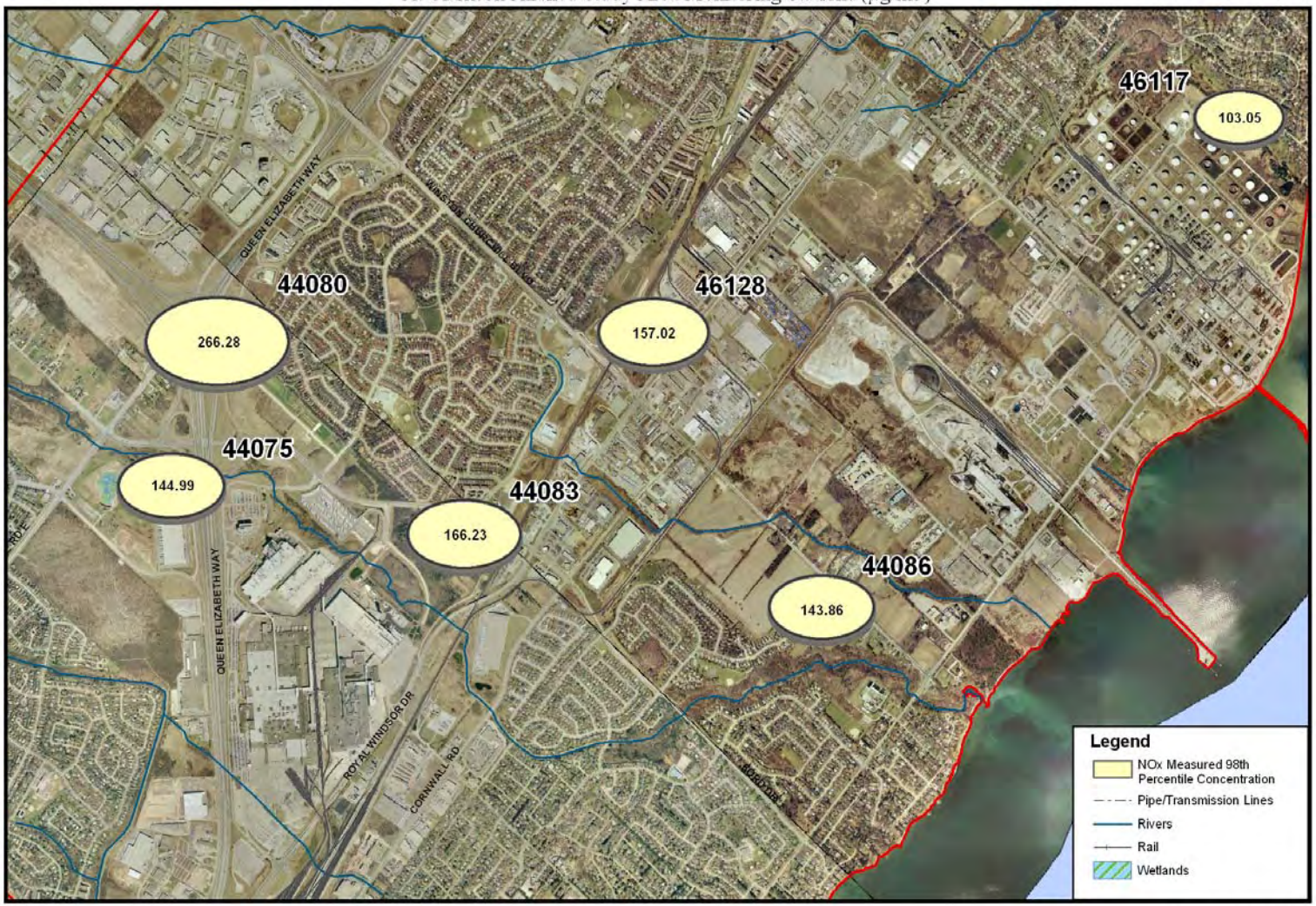
Figure 5.3 - NOx Measured 98th Percentile Concentrations
At Clarkson Airshed Study Area Monitoring Stations (µg/m3)

Ministry of the Environment



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Latitude of Origin: 0
1983 North American Datum

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Figure 5.4 - VOC Measured 98th Percentile Concentrations
At Clarkson Airshed Study Area Monitoring Stations (µg/m3)

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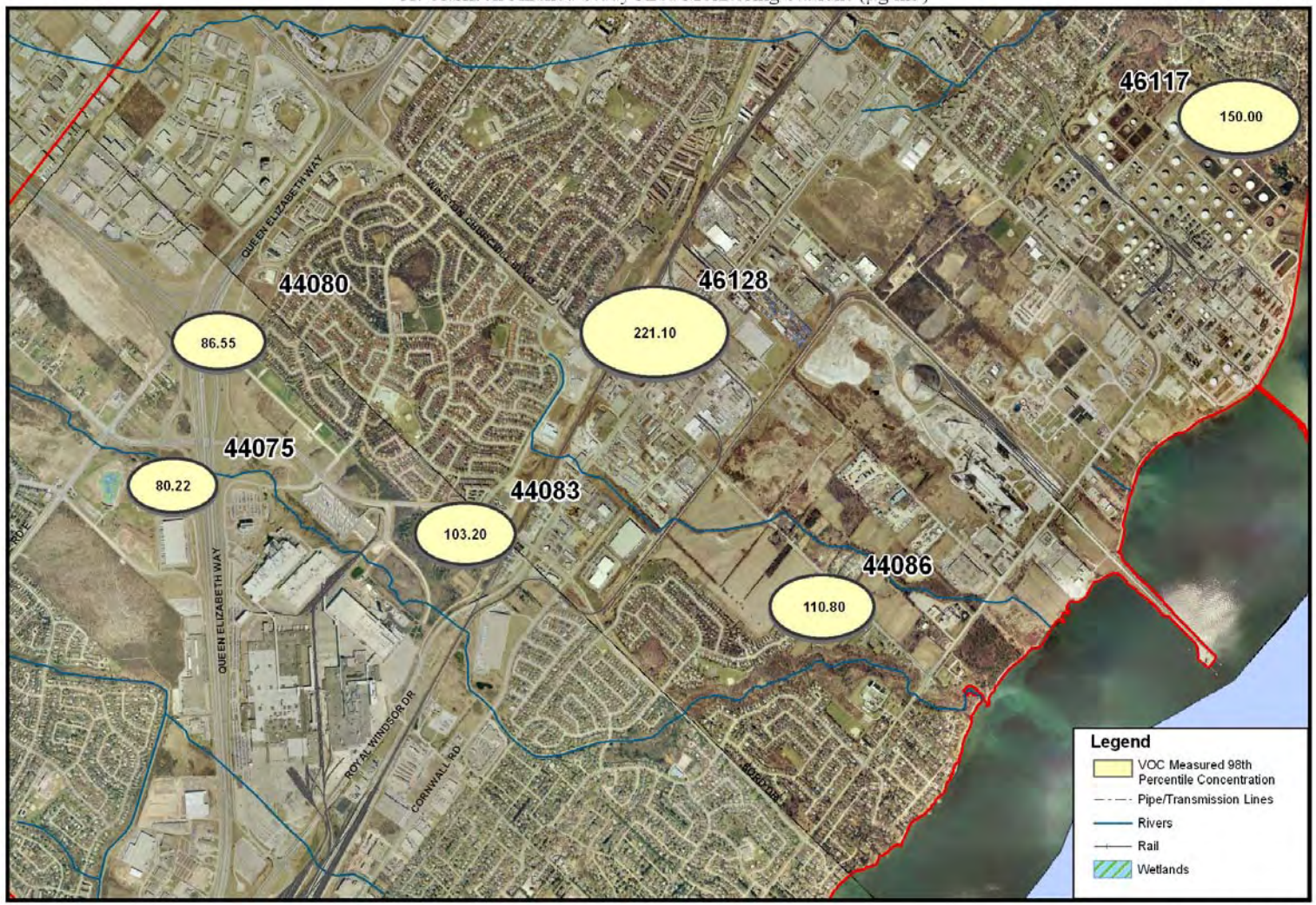

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Universal Transverse Mercator
Zone 17
False Easting: 500000m
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Central Meridian: -81
Scale Factor: 0.9996
Latitude of Origin: 0
1983 North American Datum

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Figure 5.5 Isopleth - Annual Average PM_{10} Predicted Concentrations ($\mu g/m^3$)

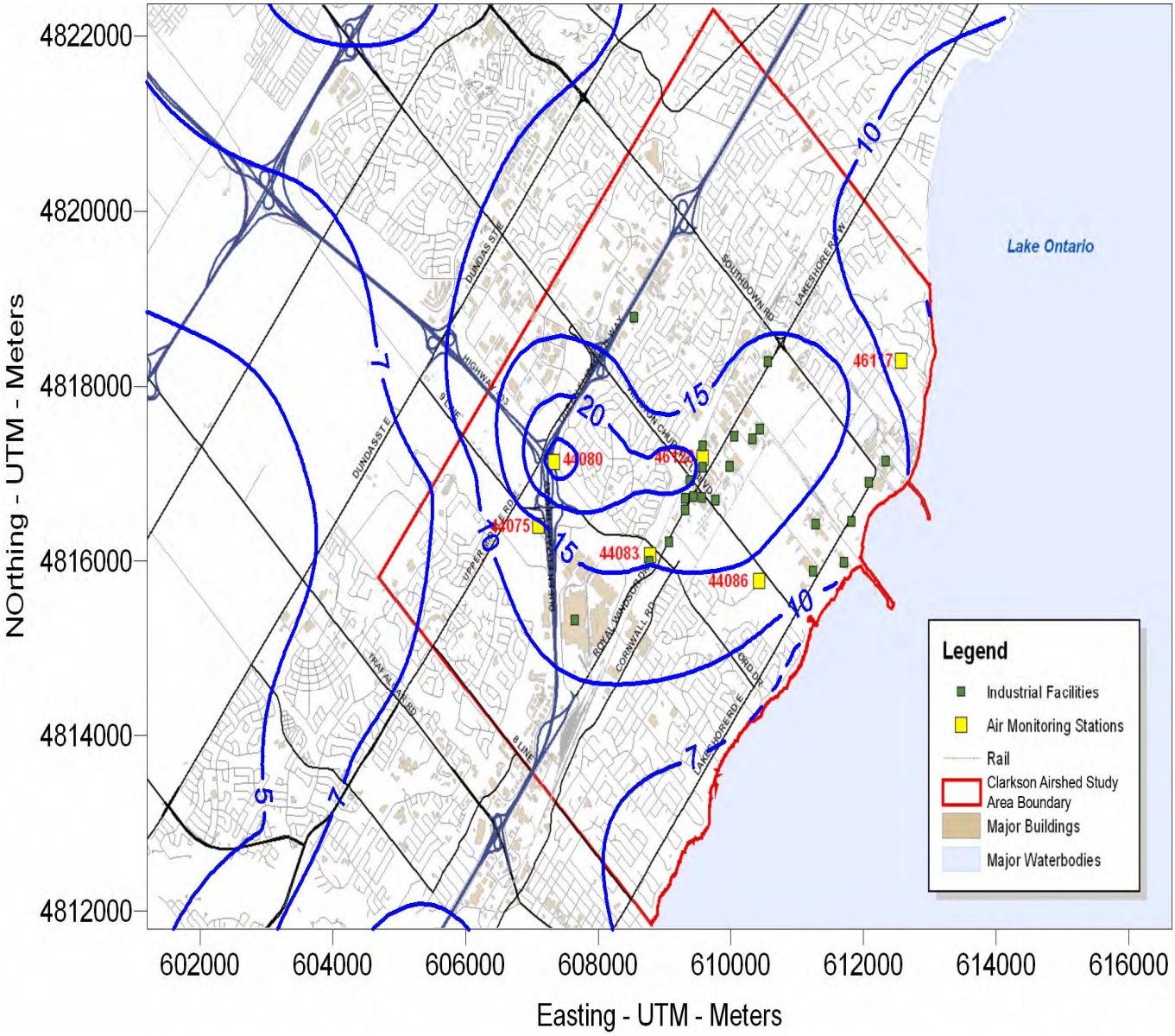


Figure 5.6 Isopleth - Annual Average $PM_{2.5}$ Predicted Concentrations ($\mu g/m^3$)

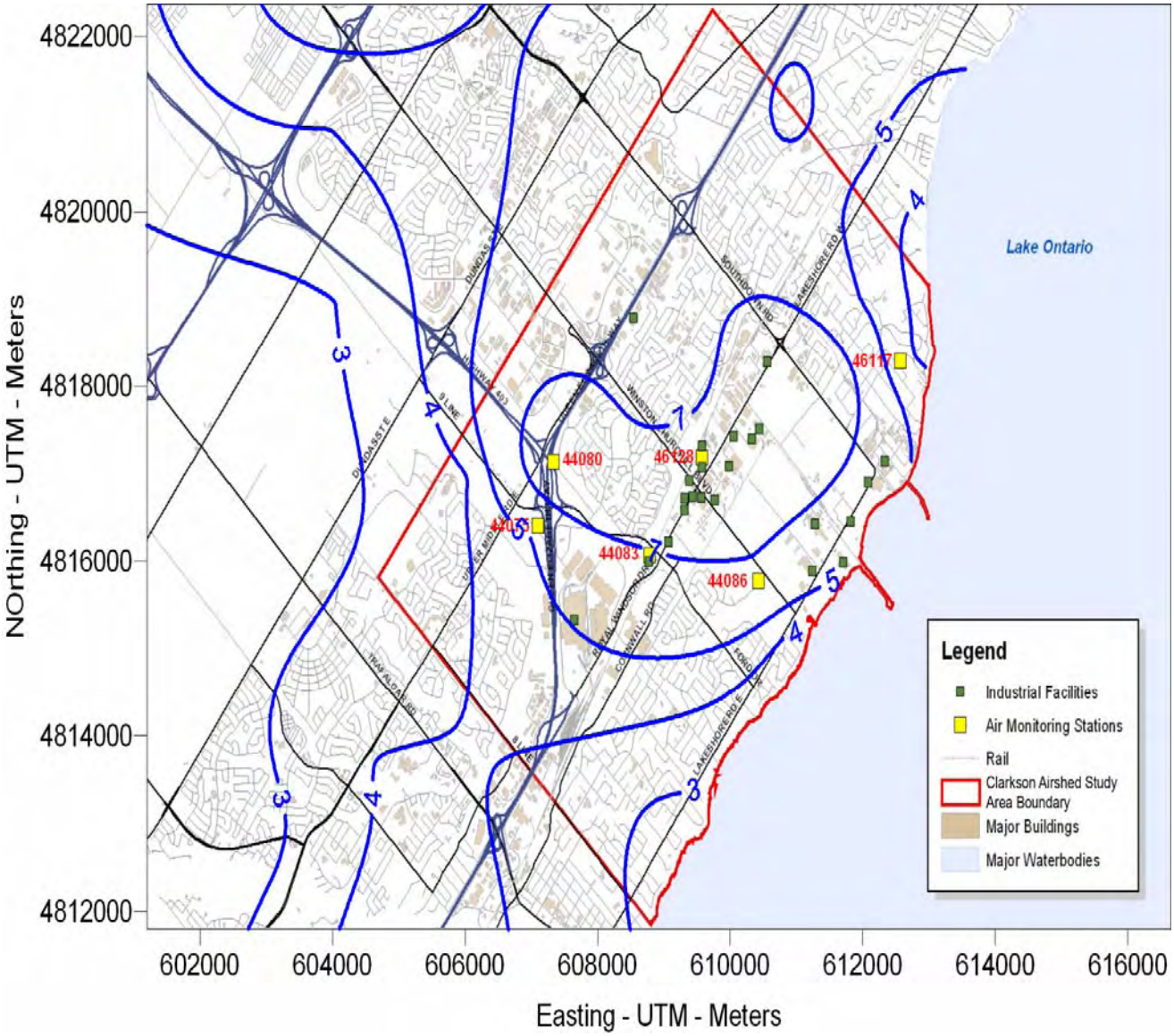


Figure 5.7 Isopleth - Annual Average NO_x Predicted Concentrations (µg/m^3)

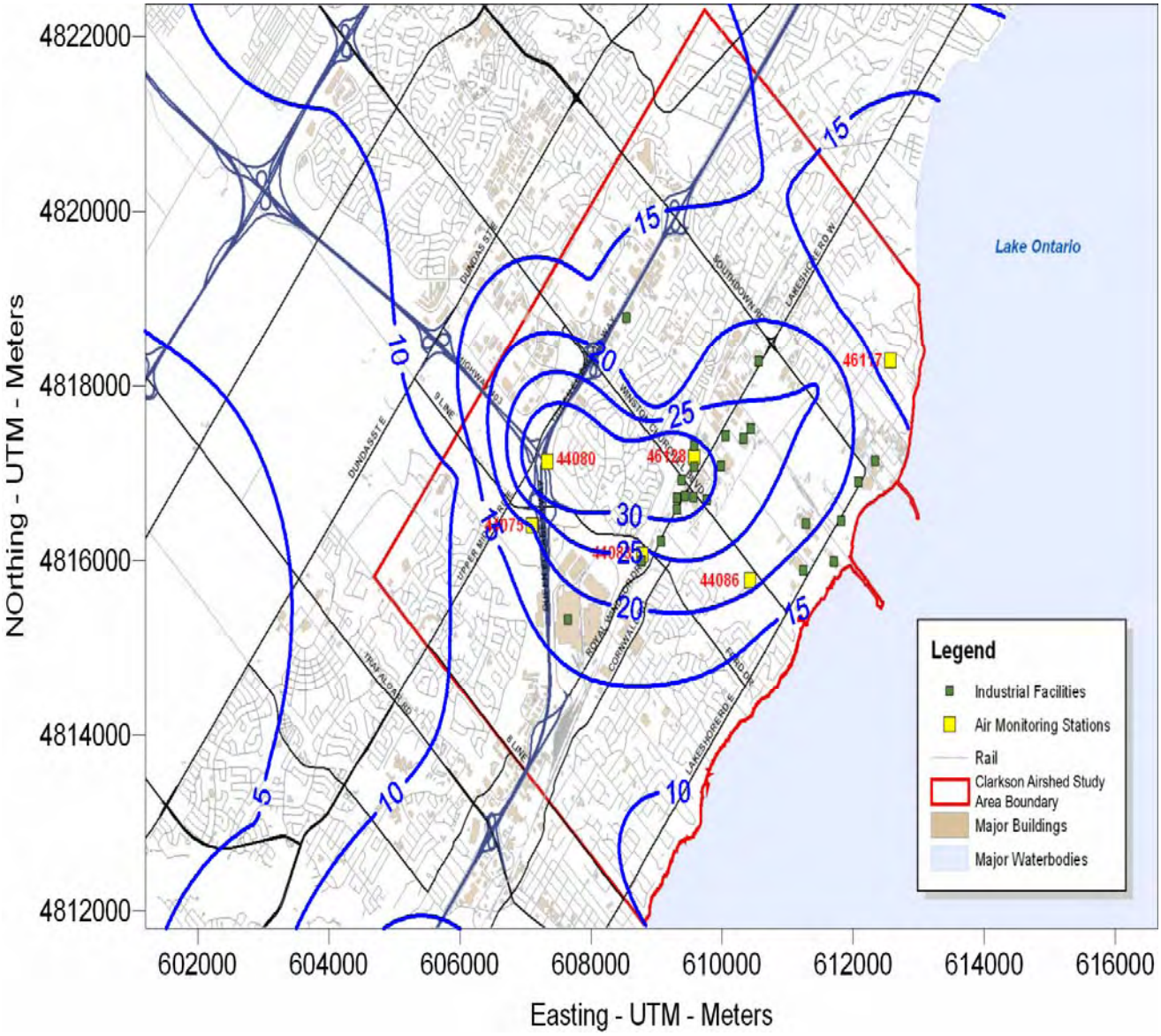


Figure 5.8 - Annual Average VOC Predicted Concentrations (µg/m^3)

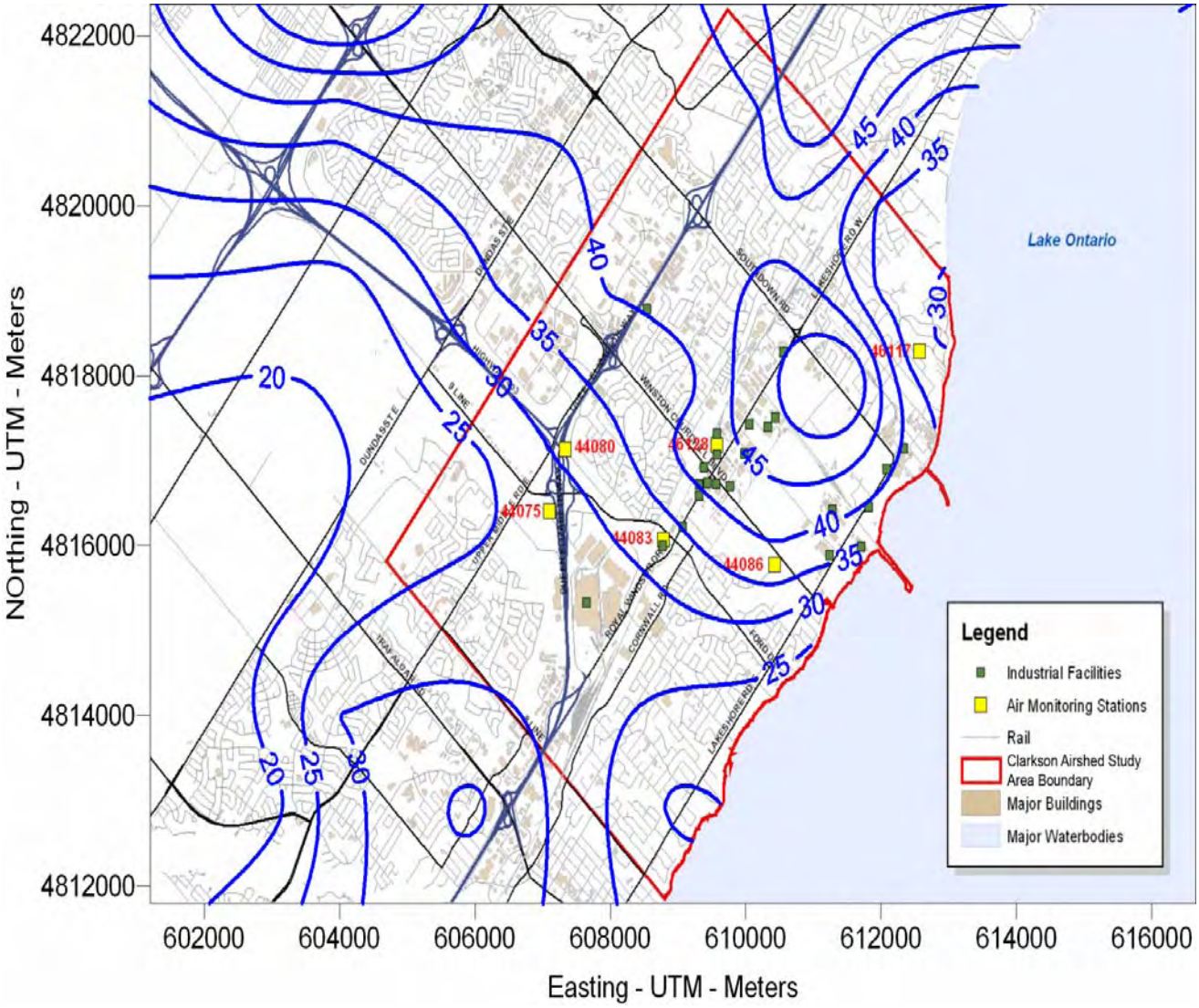


Figure 5.9 Bias Analysis For Maximum 24 Hour Average Concentrations For PM_{10}, $PM_{2.5}$, NO_x and VOCs

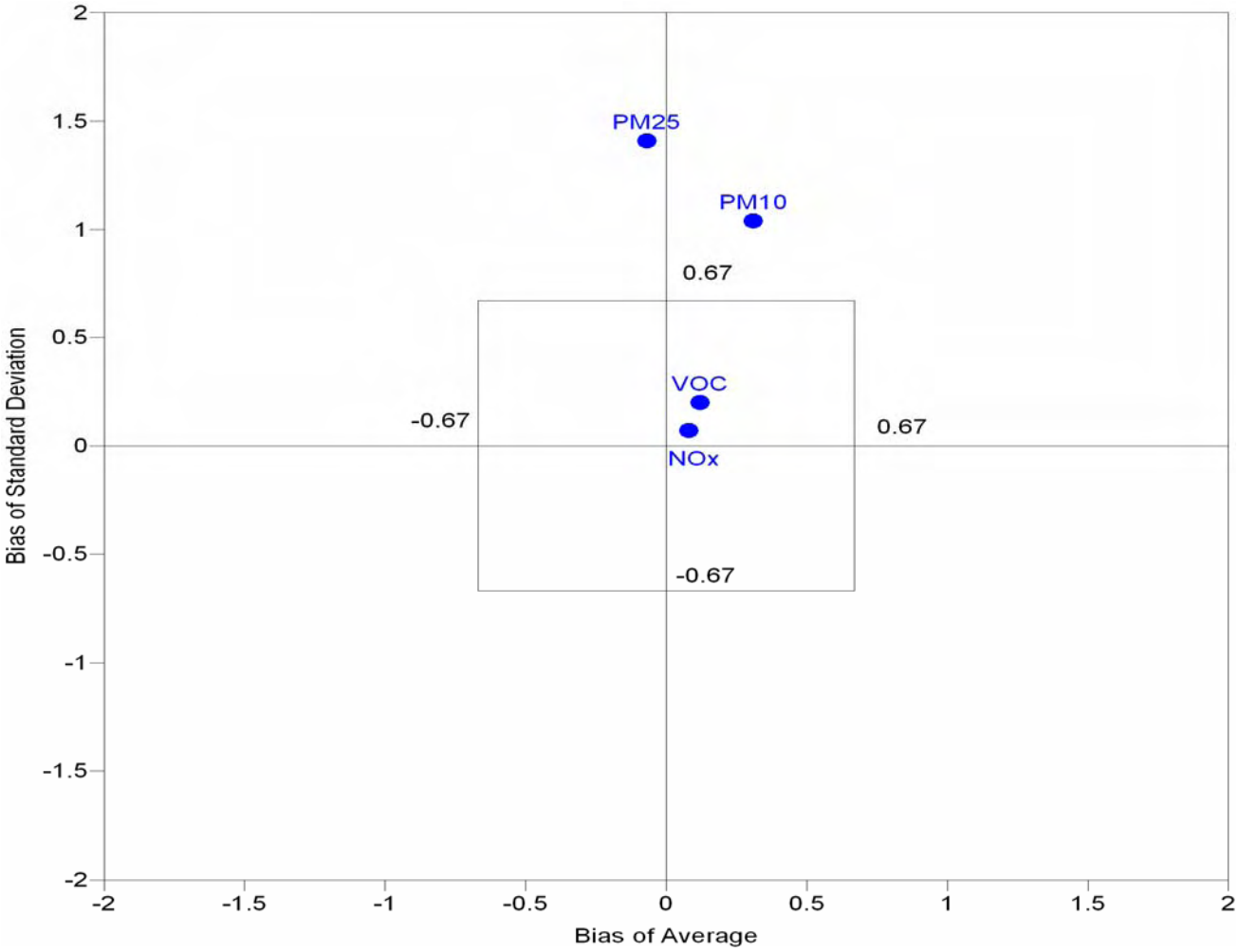


Figure 5.10 Bias Analysis For Annual Average Concentrations For PM_{10}, $PM_{2.5}$, NO_X and VOCs

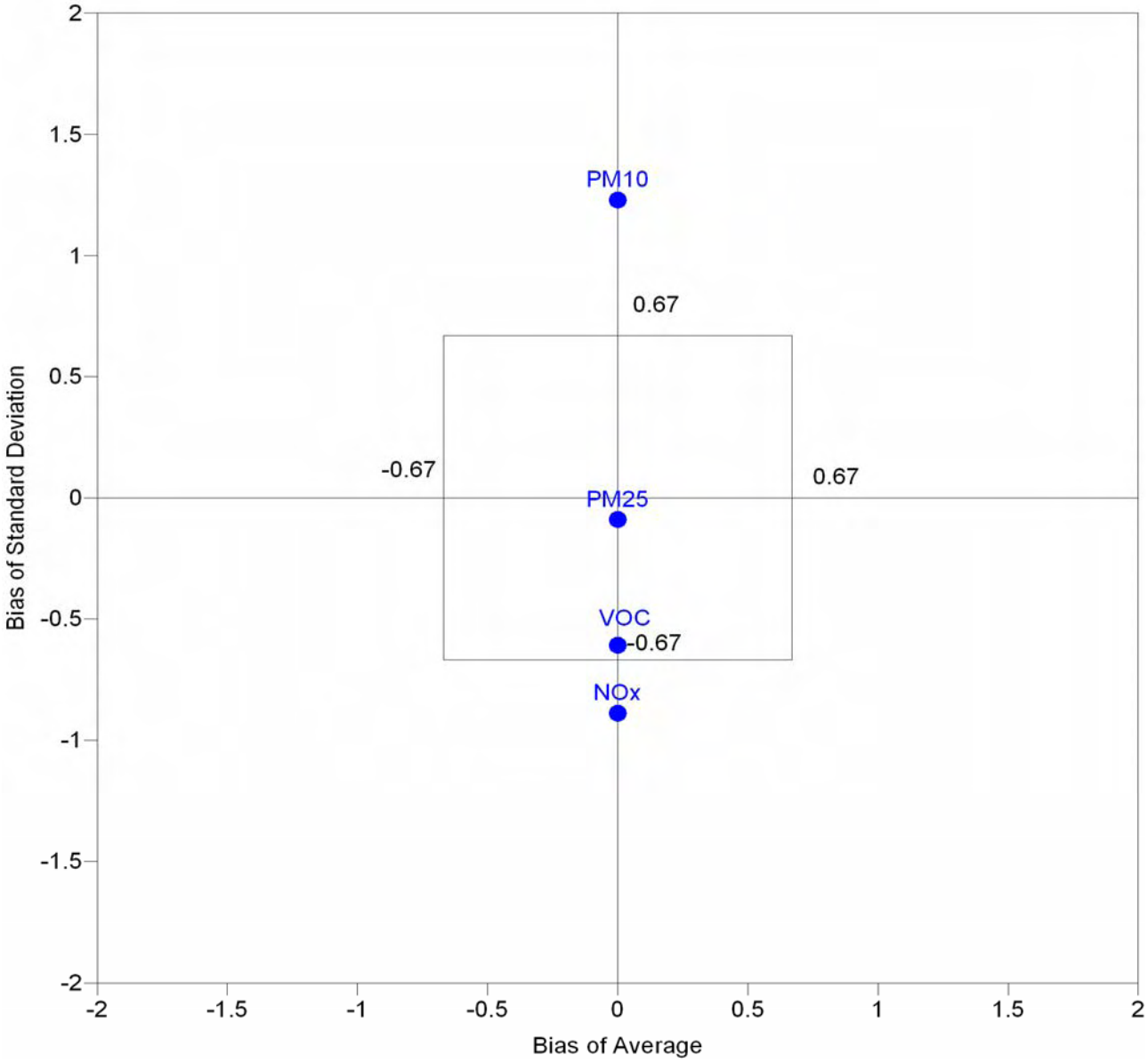


Figure 5.11 Q-Q Plots For $PM_{2.5}$ 24 Hour Concentrations

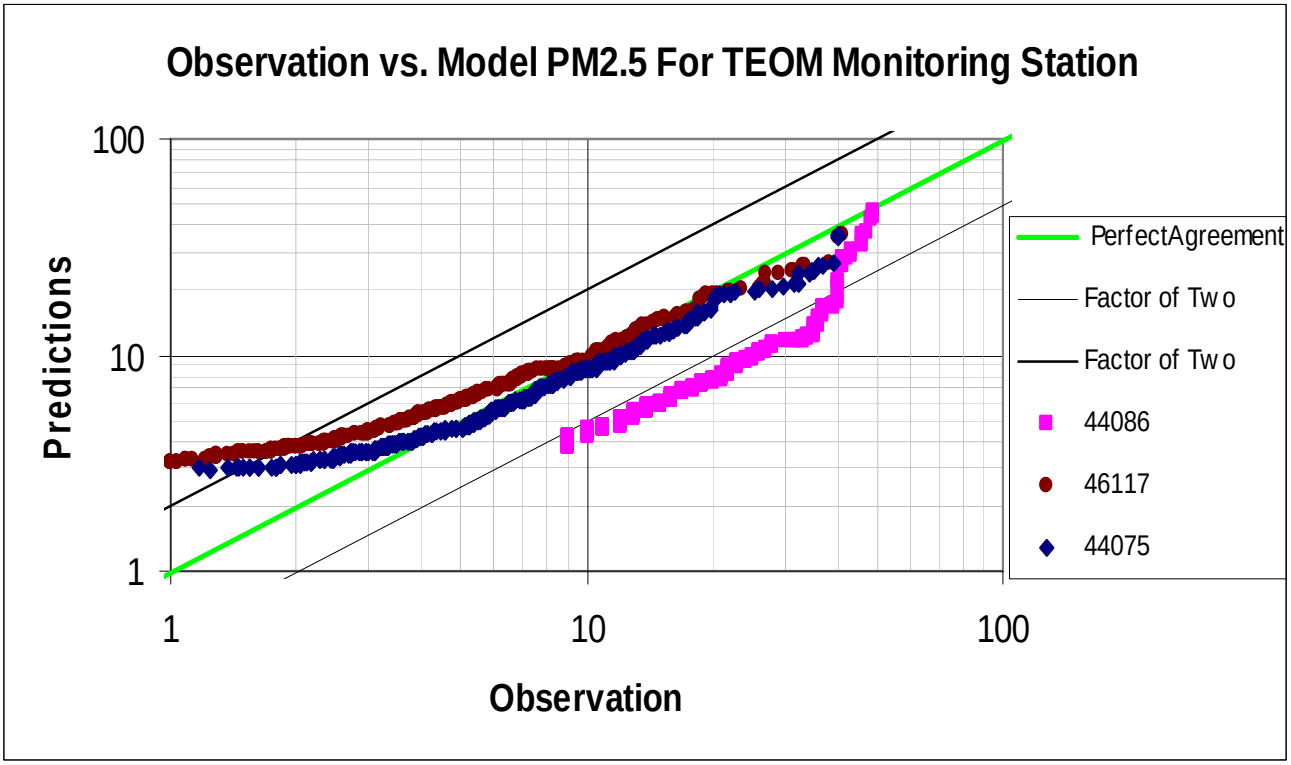
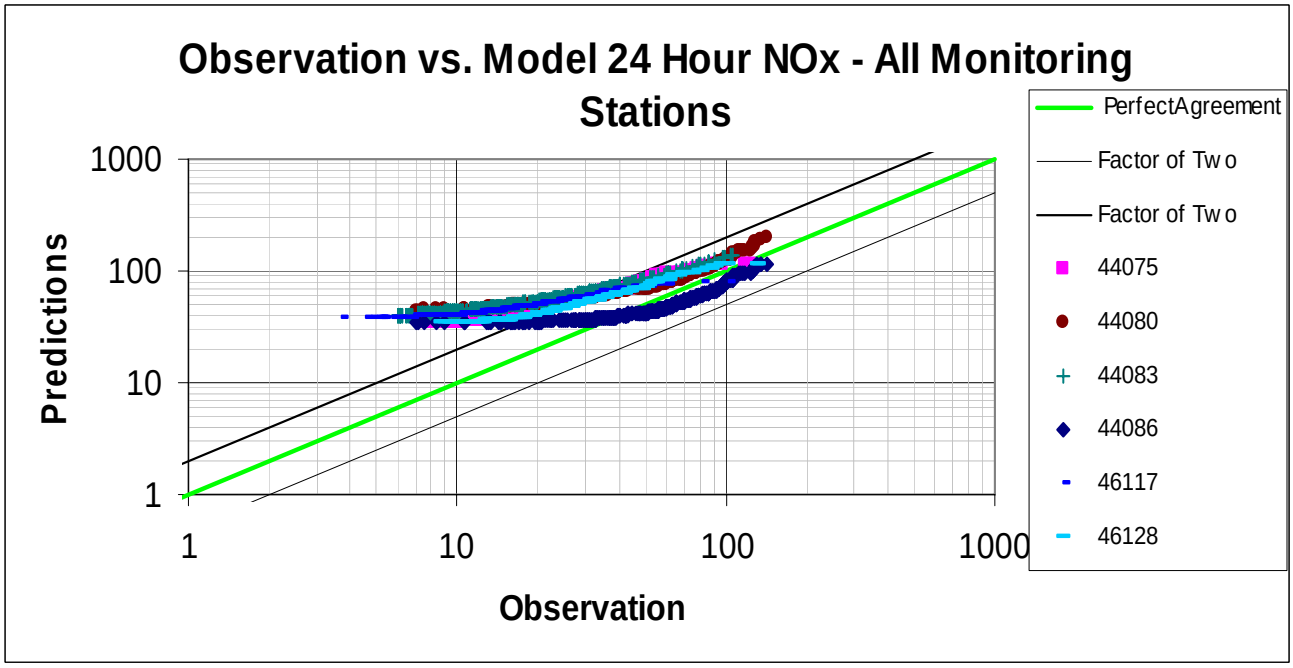


Figure 5.12 Q-Q Plots For NO_x 24 Hour Concentrations



Section - Six

Assessment Results - Transport of Contaminants Into the Clarkson Airshed Study Area

Clarkson Airshed Study: Part III – The Air Quality Dispersion Modeling Source Contribution Assessment

6.0 Introduction

Respirable fine particulate ($PM_{2.5}$) is an important consideration in the Clarkson Airshed. Therefore, it was considered useful as part of this assessment to investigate the potential magnitude of the contribution to $PM_{2.5}$ concentrations with respect to sulphates and nitrates. This respirable portion of fine particulate was recognized as being the result of emissions from both "locally derived" sources, that is sources within and around the Clarkson Airshed study area, and from sources located outside the study area at "long-range".

6.1 Contributions from "Locally Derived" Sources

In order to effectively address the sulphate/nitrate dispersion issue, the meso-puff chemistry scheme incorporated in the CALPUFF model was used. This scheme involves a linear transformation of sulphur dioxide (SO_2) to sulphates and transformation of nitrogen oxides (NO_x) to nitrates. Predicted sulphates and nitrates were compared to the total measured $PM_{2.5}$ concentrations and also for context, to the measured levels of sulphates and nitrates as determined by the USA "Improve Network".

For this part of the assessment, the SO_2 emission data base was compiled from Environment Canada data with the assumption that SO_2 emissions were equally distributed along point sources

from each individual industry (see Appendix A Table A.1). Also, based on the ammonia monitoring at Environment Canada's National Air Pollution Surveillance (NAPS) station # 60427, the background concentrations were derived for input to the CALPUFF model. A background annual average concentration of 3.59 ppb of ammonia (NH_3) was used for the nitrates and for the sulphate predictions, the SO_2 emissions from the Clarkson Airshed study area were used.

The estimated contribution of locally predicted sulphates and nitrates to the total $PM_{2.5}$ measured in the Clarkson Airshed study area are presented in Table 6.1.

Table 6.1 Predicted SO_4 and NO_3 Concentrations (ug/m^3) At Ministry Monitoring Stations

Station Number	Measured $PM_{2.5}$ (μ/gm^3)	SO_4 (μg/m^3)	NO_3 (μg/m^3)	$SO_4 + NO_3$ (μg/m^3)	($SO_4 + NO_3$) as Percent of Total Measured $PM_{2.5}$
44075	8.0	7.48E-02	4.30E-01	.51	6.4
44080	12.8	8.22E-02	4.59E-01	.54	4.2
44083	10.8	9.22E-02	4.50E-01	.54	5.0
44086	8.7	1.16E-01	4.22E-01	.54	4.9
46117	6.4	1.16E-01	3.86E-01	.50	6.3
46128	11.2	1.08E-01	4.88E-01	.60	4.5

Although only semi-quantitative, the foregoing analysis suggests that it is reasonable to consider that locally derived sulphate and nitrate particulate represents on the order of 4 – 6% of total measured $PM_{2.5}$ at the Ministry's six Clarkson Airshed monitoring stations.

Figure 6.1 (a) Sulphates Measurements From USA "Improve Network" μg/m^3

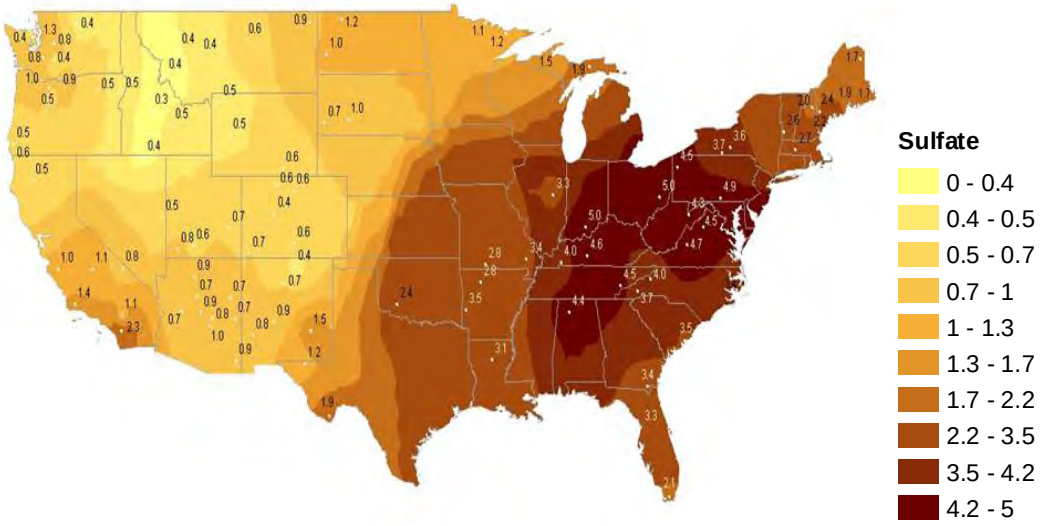
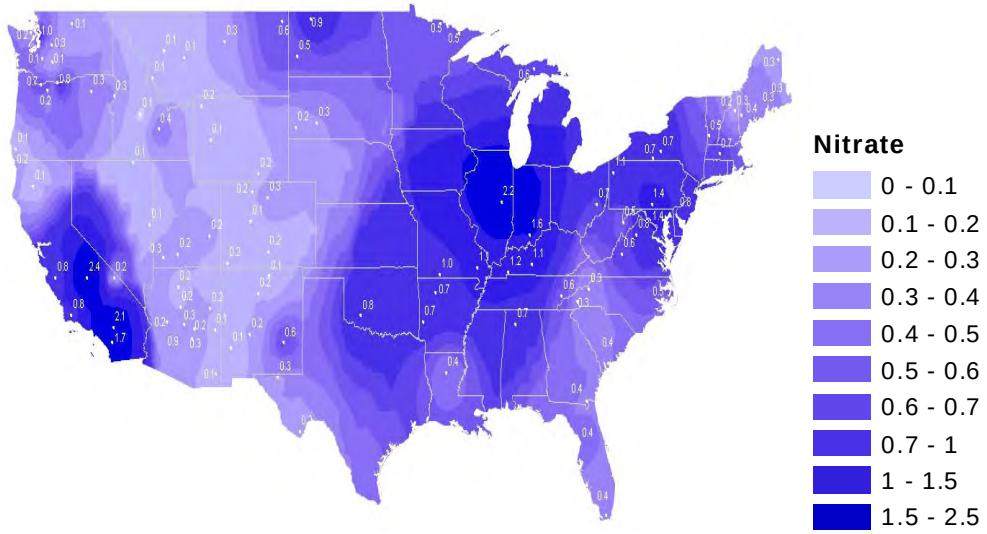


Figure 6.1 (b) Nitrates Measurements From USA "Improve Network" µg/m^3



Figures 6.1 (a) and 6.1 (b) adapted from (N. Frank, 2004)

The predictions of locally derived nitrate levels appear to be comparable to the results from monitoring data in the USA - IMPROVE Network (N. Frank, 2004) for locally derived concentrations presented in Figure 6.1b. However, the locally derived sulphate values appear to be somewhat less than might be expected in terms of data presented in Fig 6.1a.

6.2 Contributions From Outside of the Clarkson Airshed Study Area

It is well recognized that air quality in the Clarkson Airshed study area is greatly influenced by sources outside of the study area, especially those from thermal generating stations and automotive sources in the Midwest USA (e.g. MOE 2006). In this assessment, concentrations arising from sources outside of the Clarkson Airshed study area for each contaminant were calculated as the average difference between measured and predicted concentrations at the six Ministry Part II Ambient Air Monitoring Stations. The results of these calculations are presented in Table 6.2.

Table 6.2 Contaminant Concentrations in the Clarkson Airshed Study Area* Resulting From Sources Outside of the Study Area (µg/m^3)

PM_{10}	$PM_{2.5}$	NO_x	VOC
2.7	3.8	37.7	16.7

Notes: The same values are used for Maximum 24 Hour and Annual Concentrations.

NO_x emissions equivalent to NO_2

PM_{10} emissions are lower than $PM_{2.5}$, this reflects the uncertainties found in both the measurements and modelling data.

More specifically, if it is further assumed that sulphates and nitrates from locations such as the Ohio Valley (thought to be in the order of ~4 $\mu g/m^3$ as represented by the $PM_{2.5}$ value in Table 6-2) can be transported to the Clarkson Airshed Study area, then, at least on occasion, in the order of 50% or more of the measured $PM_{2.5}$ can be attributed to long-range transport from the USA.

As shown in Table 6-2, PM_{10} emissions are lower than $PM_{2.5}$. The Ministry recognizes that PM_{10} should be higher than $PM_{2.5}$, however the discrepancy may simply reflect minor uncertainties in both the measurement and prediction data.

Section - Seven

Conclusions & Next Steps

Clarkson Airshed Study: Part III – The Air Quality Dispersion Modeling Source Contribution Assessment

7.0 Conclusions

Using the CALMET/CALPUFF air dispersion modeling system, a comprehensive inventory of air emissions and a defined source sector approach, the Ministry has effectively defined a credible allocation of source contributions to the measured ambient air monitoring data collected in Part II of the Clarkson Airshed Study.

In this regard, Part III of the Clarkson Airshed Study – The Air Dispersion Modelling Source Contribution Assessment, as documented in this report, has been successful in developing a source contribution data base that will assist Ministry district abatement staff in moving forward with Part IV of the Clarkson Airshed study which is to "go beyond compliance" in reducing industry contributions to air quality contaminant concentrations in the area.

More so than any other part of the Clarkson Airshed Study, the conclusions reached during Part III are particularly tied to the approach taken in completing the work. The key components of the Part III assessment that defined our approach to developing the source contribution data base were:

(i) The definition of 4 source sectors – (a) Industrial (process stack emissions, process and vehicle/road dust fugitive emissions); (b) Vehicular (tailpipe and surface re-suspended road dust emissions from travel on public roadways); (c) Residential (heating); and (d) Miscellaneous (a general category which may include such sources as: dry cleaning, fuel marketing, general solvent use, pesticides and fertilizer applications etc).

(ii) The selection of 10 individual industry sources located in the area, considered as important contributors to Industrial sector emissions.

(iii) The identification of key contaminants of interest, namely: (a) particulate matter less than or equal to 10 microns in size (PM_{10}), (b) particulate matter less than or equal to 2.5 microns ($PM_{2.5}$), (c) nitrogen oxides (NO_x) and (d) total volatile organic compounds (VOCs).

(iv) The development of a comprehensive inventory of all significant air emissions sources located both within and in the vicinity of, the Clarkson Airshed study area.

(v) The use of the CALMET/CALPUFF dispersion modeling system (version 5.711a) to develop predicted contaminant concentrations and help define the contributions of the various source sectors to air quality in the airshed study area.

The entire Part III assessment focused on the use of measured 2004 data collected during the Part II Ambient Air Monitoring Program and dealt with annual average and 98th percentile, 24 hour contaminant concentrations. The year 2004 is the only complete year for which Part II monitoring data were available.

In developing the source contribution data, on the basis of a contaminant by contaminant evaluation, the results in terms of the selected source sectors were effectively traceable to the locations of the Clarkson Airshed Study Part II monitoring station locations. What was also evident was the fact that the model performed quite reasonably in allowing the Ministry to estimate measured or monitored values from predicted values.

For the four source sectors evaluated in the Part III assessment, the most significant contributor to contaminant concentrations measured at the Ministry monitoring stations was the Vehicular sector. This was true for PM_{10}, $PM_{2.5}$ and NOx emissions and accounted for about 50-70% of the total measured contaminant values. In this regard, the Industrial Sector accounted for only 25-35% of the total measured values. The Miscellaneous source sector dominated the measured VOC contaminant concentrations accounting for about 40% of the total measured values.

Since the impacts from vehicular traffic related to particulate matter and nitrous oxides were so significant, further study and analysis is required in order to address potential mitigation approaches for this source sector and to validate the uncertainties in the fugitive emission data (postal code CAC database) used in the Part II assessment.

Of the total contaminant concentrations, long-range or transboundary sources and sources outside of the Clarkson Airshed study area accounted for about 15-60% of the measured values. For example, at least on occasion, in the order of 50% or more of the measured $PM_{2.5}$ was attributed to long-range transport from the USA.

Looking in more detail at the source sector data for each contaminant:

(i) The Vehicular sector contributed the highest average percentage (65%) of the total PM_{10} measured (98^{th} percentile concentration of 34.28 $\mu g/m^3$ versus overall 98^{th} percentile value of 50.52 $\mu g/m^3$). The Industrial Sector was the next highest with an average of 26% and the Residential sector contributed an average of about 8%. Sources outside of the study area contributed approximately 15% when compared to the measured data.

(ii) The Vehicular sector contributed the highest average percentage (49%) of the total $PM_{2.5}$ measured (98^{th} percentile concentration of 17.08 $\mu g/m^3$ and versus the 98^{th} percentile value of 33.97 $\mu g/m^3$). The Industrial sector contributed an average of about 32% and Residential 19%. Sources of $PM_{2.5}$ outside the study area were thought to play a more important role than sources of PM_{10} and contributed an average of approximately 39% of the total observed. A significant proportion of this percentage was thought to be from the long range transport of sulphates and nitrates (Canada U.S. Air Quality Committee 2004).

(iii) The Vehicular sector contributed the highest average percentage (68%) of the total NO_x measured (98^{th} percentile concentration of 117.09 $\mu g/m^3$ versus the overall 98^{th} percentile value of 163.61 $\mu g/m^3$). The Industrial sector contributed an average of about 30% and the Residential sector an average of 3%. Sources outside the Clarkson Airshed contributed approximately 63% to the total observed.

(iv) The Miscellaneous sector contributed the highest average percentage (43%) of the total VOC measured (98^{th} percentile concentration of 51.87 $\mu g/m^3$ versus the overall 98^{th} percentile value of 125.31 $\mu g/m^3$). The Industrial sector contributed an average of about 36%; Vehicular an average of 12% and Residential an average of 9%. Transport into the airshed from outside sources was on the average of about 34% or 1/3 of the total VOCs measured.

One of most important data sets coming out of the Part III assessment relates to specific contributions of the 10 individual industries. Not only was this information important in defining some of the industries that had the most impact on the air quality of the Clarkson Airshed study area, but it is also important in the development of a "Industrial Source Contribution Matrix" which will help the Ministry District Office in tracking improvements in air quality as Part IV of the Clarkson Airshed Study progresses.

Of the 10 individual industries addressed, the key contributors to the contaminant concentrations measured at the six Ministry monitoring stations were: St. Lawrence Cement, Petro Canada, Ford, Universal Drum and, Stackpole. The order in which these companies were ranked with respect to concentrations of the four (4) key contaminants is presented in Table 7.1.

An example of the Industrial Source Contribution Matrix for the measured 98th percentile contaminant concentrations is shown in Table 7.2 for the top three companies as it relates to the contribution to predicted and measured $PM_{2.5}$ concentrations.

Table 7.1 Top Three Ranked Industries in Clarkson Airshed Study Area In Terms of the Highest Contributors to Contaminant Concentrations Measured at the Ministry Monitoring Stations

Contaminant	Top Three Companies		
	1st	2nd	3rd
PM_{10}	St. Lawrence Cement	Ford	Stackpole
$PM_{2.5}$	St. Lawrence Cement	Stackpole	Ford
NO_x	St. Lawrence Cement	Petro Canada Lubricants	Ford
VOC	Ford	Petro Canada Lubricants	Universal Drum

The matrix as depicted in Table 7.2 can effectively be used for screening the effect of changes to emissions from local industry sources from the standpoint of process optimization and continuing efforts to reduce emissions.

Table 7.2 Industrial Source Contribution Matrix -$PM_{2.5}$ Measured 98th Percentile Concentrations (µg/m^3)

Individual Industries	Overall Contribution Of Industries		Industry Source Contribution to PM2.5 Measured Concentrations at Ministry Monitoring Stations											
			44075		44080		44083		44086		46117		46128	
	Avg %	Avg Conc.	%	µg/m^3	%	µg/m^3	%	µg/m^3	%	µg/m^3	%	µg/m^3	%	µg/m^3
5 – Ford	12	0.03	26	0.19	14	0.07	20	0.28	3	0.06	2	0.04	6	0.04
8 – St. Lawrence Cement	61	0.20	52	0.37	57	0.27	61	0.86	73	1.41	64	1.22	58	0.42
9 – Stackpole Limited	13	0.04	8	0.06	12	0.06	8	0.11	15	0.29	11	0.21	21	0.15
Total Measured $PM_{2.5}$ Individual Industry 98th Percentile Conc. at Monitoring Station [µg/m^3]			**0.72**		**0.47**		**1.41**		**1.93**		**1.90**		**0.73**	

The two most significant air emissions sources on either side of the Clarkson Airshed study area are the Lakeview Generating Station and the Petro Canada Oakville refinery. These two sources have been often suggested as being significant factors impacting air quality within the study area. However, the results of the Part III assessment do not support this suggestion and in fact, indicate that <.1 to 6% of all contaminant concentrations measured in the study area were attributed to

Lakeview Generating Station and the Petro Canada refinery with the maximum impact occurring at Station 46117 for $PM_{2.5}$.

Another key indicator of the success of the Part III assessment, was the accuracy of predicted concentrations as compared to the measured values. Such success was represented by the fact that the CALMET/CALPUFF modelling system provided predicted concentrations that were consistently within a factor of 2 of the measured concentrations. This is the level of accuracy that is acceptable and normally expected in a modeling exercise such as this. To confirm this accuracy a statistical evaluation was completed.

From a statistical point of view, both Q-Q plots and a fractional bias approach were used to evaluate model accuracy in defining predicted values that could be reasonably compared to measured concentrations determined during Part II of the Clarkson Airshed Study. Although these approaches did not include all data generated during the assessment, both defined predicted concentrations within a factor of two (2) and therefore demonstrated that the predicted values provided a reasonable agreement, on average, with measured values.

7.1 Next Steps

Since the impacts from vehicular traffic related to particulate matter and nitrous oxides were so significant, further study and analysis is required in order to address potential mitigation approaches for this source sector and to validate the uncertainties in the fugitive emission data (postal code CAC database) used in the assessment.

Part IV of the Clarkson Airshed study began in the spring of 2007 with the establishment of the Clarkson Airshed Advisory Committee (CASAC). The Committee, which was convened by the Halton Peel District Office of the Ministry, is a multi-stakeholder partnership which meets every 2 months and includes representation from the 11 participating industries as well as representatives from the local community/municipality, politicians and staff of the local Health Units.

The mandate of the Advisory Committee is to operate an air quality management system in the Clarkson area on the basis of shared responsibility and the utilization of a consensus building, collaborative approach to improving air quality. The Committee is presently working with an environmental consultant on the development and implementation of a permanent ambient air monitoring program for the Clarkson airshed study area and vicinity.

It is also expected that towards the end of 2008 and into early 2009, participating industries will begin designing and implementing abatement programs to focus on further reductions in air emissions of the targeted pollutants.

In order to achieve better air quality in the Clarkson area, the focus of the CSAAC is to get commitments from industry to "go beyond compliance". This approach, which has been adopted in other cities such as Hamilton, will be successful if it has the cooperation of industry, commercial businesses and other levels of government.

Section - Eight

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APPENDIX A

STACK PARAMETERS

Appendix A.1
Stack Emissions and Stack Parameters

Industry	Stack No.	Stack Name	Coordinates - UTM - NAD83		Stack Height (m)	Base Elevation (m)	Stack Diameter (m)	Exit Velocity (m/s)	Exit Temp. (K)	Emission Rates (g/s)					
			Easting (m)	Northing (m)						SO_2	NO_x	PM	PM_{10}	$PM_{2.5}$	VOC
Petro Canada	1!	07PH1_ST	612.494	4817.328	30.5	80.9	0.8	32.0	622.0	1.82E+00	1.01E-01	1.07E-01	6.60E-02	4.79E-02	2.73E-01
	2!	07PH2_ST	612.491	4817.330	30.5	80.9	0.8	27.9	580.0	1.82E+00	8.29E-02	9.24E-02	5.70E-02	4.13E-02	2.73E-01
	3!	07PH31ST	612.471	4817.350	58.5	81.5	2.3	10.5	639.0	1.82E+00	3.60E-01	4.01E-01	2.48E-01	1.79E-01	2.73E-01
	4!	07PH32ST	612.473	4817.348	58.5	81.4	2.3	10.5	639.0	1.82E+00	2.93E-01	3.26E-01	2.01E-01	1.46E-01	2.73E-01
	5!	07PH33ST	612.478	4817.343	58.5	81.3	2.3	10.5	639.0	1.82E+00	1.52E-01	1.69E-01	1.04E-02	7.58E-02	2.73E-01
	6!	07PH5_ST	612.486	4817.335	30.5	81.1	0.8	28.4	575.0	1.82E+00	9.72E-02	1.08E-01	6.68E-02	4.84E-02	2.73E-01
	7!	14H101ST	612.556	4817.331	35.4	80.4	1.2	7.8	550.0	1.82E+00	7.60E-02	1.11E-01	6.87E-02	5.54E-02	2.73E-01
	8!	14H102ST	612.562	4817.331	23.8	80.4	0.9	15.6	558.0	1.82E+00	6.39E-02	9.37E-02	5.78E-02	4.66E-02	2.73E-01
	9!	16H2_PNT	612.395	4817.069	27.4	80.8	1.5	2.0	523.0	1.82E+00	4.79E-01	5.34E-01	3.29E-01	2.65E-01	2.73E-01
	10!	17SOUTH	612.660	4817.152	121.9	76.2	2.7	8.0	460.0	1.82E+00	7.65E-02	8.52E-02	5.26E-02	3.81E-02	2.73E-01
	11!	20H100ST	612.564	4817.388	30.5	81.0	0.9	4.2	546.0	1.82E+00	3.71E-02	5.44E-02	3.36E-02	2.70E-02	2.73E-01
	12!	20H101ST	612.526	4817.421	39.8	81.7	0.8	14.2	547.0	1.82E+00	9.71E-02	1.42E-01	8.78E-02	7.07E-02	2.73E-01
	13!	20H102ST	612.531	4817.416	40.6	81.6	0.8	12.3	557.0	1.82E+00	8.06E-02	1.18E-01	7.29E-02	5.87E-02	2.73E-01
	14!	28H201PN	612.320	4816.978	45.7	79.0	2.4	0.8	523.0	1.82E+00	1.49E-01	1.66E-01	1.03E-01	8.27E-02	2.73E-01
	15!	28H202PN	612.297	4816.996	45.7	79.8	2.4	0.8	523.0	1.82E+00	1.94E-01	2.16E-01	1.34E-01	1.08E-01	2.73E-01
	16!	28H203PN	612.280	4817.013	45.7	80.5	2.4	0.8	523.0	1.82E+00	1.16E-01	1.29E-01	7.98E-02	6.43E-02	2.73E-01
	17!	29H401PN	612.317	4816.986	45.7	79.3	2.4	0.8	523.0	1.82E+00	1.12E-01	1.25E-01	7.69E-02	6.19E-02	2.73E-01

Industry	Stack No.	Stack Name	Coordinates - UTM - NAD83		Stack Height (m)	Base Elevation (m)	Stack Diameter (m)	Exit Velocity (m/s)	Exit Temp. (K)	Emission Rates (g/s)					
			Easting (m)	Northing (m)						SO_2	NO_x	PM	PM_{10}	$PM_{2.5}$	VOC
	18!	29H402PN	612.287	4817.006	45.7	80.2	2.4	0.8	523.0	1.82E+00	9.05E-02	1.01E-01	6.22E-02	5.01E-02	2.73E-01
	19!	30NORTH	612.413	4817.358	121.9	82.4	3.7	11.5	418.0	1.82E+00	1.26E+01	9.18E-02	4.12E-01	2.39E-01	2.73E-01
	20!	41H504ST	612.315	4817.358	30.5	83.8	1.2	7.2	505.0	1.82E+00	7.30E-03	8.13E-03	5.02E-03	3.64E-03	2.73E-01
	21!	41H506ST	612.310	4817.601	45.7	83.0	1.5	1.8	539.0	1.82E+00	2.37E-02	2.64E-02	1.63E-02	1.18E-03	2.73E-01
	22!	HBON_PNT	612.519	4817.363	10.0	81.0	2.0	11.2	523.0	1.82E+00	0.00E+00	6.15E-02	7.58E-03	1.52E-03	2.73E-01
	23!	98ZTOF	612.732	4817.409	17.0	79.4	10.5	0.7	419.0	1.82E+00	1.49E-02	0.0E+00	0.00E+00	0.00E+00	2.73E-01
	24!	567BF3	611.341	4816.391	43.0	91.0	2.7	15.4	347.0	2.36E+00	0.00E+00	2.90E-01	2.18E-01	9.77E-02	0.00E+00
	25!	ABP	611.153	4816.398	85.0	91.2	2.0	13.5	444.1	2.36E+00	6.52E+00	2.63E-02	1.96E-02	1.33E-02	1.36E-02
SLC	26!	AFMSTK	611.262	4816.507	67.0	95.5	2.3	15.1	360.1	2.36E+00	8.36E+00	1.12E-01	8.33E-02	5.64E-02	4.23E-03
	27!	B3441	611.247	4816.474	27.1	94.8	5.1	0.01	293.0	2.36E+00	0.00E+00	1.68E-02	1.26E-02	5.64E-03	0.00E+00
	28!	B4541	611.254	4816.466	27.1	94.5	5.1	0.01	293.0	2.36E+00	0.00E+00	1.68E-02	1.26E-02	5.66E-03	0.00E+00
	29!	B5241	611.265	4816.467	21.4	94.6	21.9	0.01	360.0	2.36E+00	0.00E+00	4.74E-02	3.37E-02	1.51E-02	0.00E+00
	30!	B579	611.247	4816.482	18.4	95.1	37.4	0.01	360.0	2.36E+00	0.00E+00	1.30E-01	9.80E-02	4.39E-02	0.00E+00
	31!	C5241	611.338	4816.229	68.6	87.1	24.5	0.01	380.0	2.36E+00	0.00E+00	5.57E-02	4.19E-02	1.88E-02	0.00E+00
	32!	CCSTACK	611.293	4816.280	77.0	89.2	2.4	25.0	420.1	2.36E+00	0.00E+00	7.22E-02	5.40E-02	3.65E-02	0.00E+00

Industry	Stack No.	Stack Name	Coordinates - UTM - NAD83		Stack Height (m)	Base Elevation (m)	Stack Diameter (m)	Exit Velocity (m/s)	Exit Temp. (K)	Emission Rates (g/s)					
			Easting (m)	Northing (m)						SO_2	NO_x	PM	PM_{10}	$PM_{2.5}$	VOC
	33!	CRUSH A	611.121	4816.564	11.1	92.4	24.5	0.01	293.0	2.36E+00	0.00E+00	5.57E-02	4.20E-02	1.88E-02	0.00E+00
	34!	CRUSH B	611.108	4816.551	11.1	92.9	24.5	0.01	293.0	2.36E+00	0.00E+00	5.57E-02	4.20E-02	1.88E-02	0.00E+00
	35!	CRUSH C	611.116	4816.578	11.1	91.8	20.5	0.01	293.0	2.36E+00	0.00E+00	2.59E-04	1.09E-04	1.38E-04	0.00E+00
	36!	D171	611.277	4816.454	22.8	94.3	33.3	0.01	360.0	2.36E+00	0.00E+00	1.30E-01	9.80E-02	4.39E-02	0.00E+00
	37!	D172	611.285	4816.446	22.8	94.1	33.3	0.01	360.0	2.36E+00	0.00E+00	1.30E-01	9.80E-02	4.39E-02	0.00E+00
	38!	D173	611.293	4816.438	22.8	93.9	33.3	0.01	347.0	2.36E+00	0.00E+00	1.30E-01	9.80E-02	4.39E-02	0.00E+00
	39!	D174	611.303	4816.428	22.8	93.5	25.8	0.01	349.0	2.36E+00	0.00E+00	7.28E-03	5.45E-03	2.45E-03	0.00E+00
	40!	D175	611.309	4816.415	26.7	92.9	1.1	14.5	347.0	2.36E+00	0.00E+00	1.52E-01	1.14E-01	5.10E-02	0.00E+00
	41!	D5201	611.305	4816.411	25.7	92.9	0.8	16.5	347.0	2.36E+00	0.00E+00	9.47E-02	7.13E-02	3.20E-02	0.00E+00
	42!	D5221	611.323	4816.426	31.1	92.6	0.8	17.3	347.0	2.36E+00	0.00E+00	1.01E-01	7.55E-02	3.39E-02	0.00E+00
	43!	D6301	611.322	4816.414	31.1	92.3	0.8	20.1	347.0	2.36E+00	0.00E+00	4.03E-02	3.03E-02	1.36E-02	0.00E+00
	44!	D6321	611.327	4816.419	31.1	92.2	0.8	48.2	347.0	2.36E+00	0.00E+00	8.05E-02	6.08E-02	2.72E-02	0.00E+00
	45!	E2611	611.364	4816.556	14.0	91.3	24.5	0.01	346.5	2.36E+00	0.00E+00	5.57E-02	4.20E-02	1.88E-02	0.00E+00

Industry	Stack No.	Stack Name	Coordinates - UTM - NAD83		Stack Height (m)	Base Elevation (m)	Stack Diameter (m)	Exit Velocity (m/s)	Exit Temp. (K)	Emission Rates (g/s)					
			Easting (m)	Northing (m)						SO_2	NO_x	PM	PM_{10}	$PM_{2.5}$	VOC
	46!	E544	611.366	4816.548	26.8	91.4	18.8	0.01	346.7	2.36E+00	0.00E+00	3.26E-02	2.47E-02	1.10E-02	0.00E+00
	47!	E545	611.370	4816.552	26.8	91.1	18.8	0.01	346.7	2.36E+00	0.00E+00	3.26E-02	2.47E-02	1.10E-02	0.00E+00
	48!	MAIN	611.154	4816.465	169.0	94.0	4.0	17.9	401.1	2.36E+00	3.15E+01	2.53E-01	1.88E-01	1.28E-01	1.12E+00
	49!	QU420	611.271	4816.525	8.9	94.9	4.0	0.0	373.1	2.36E+00	1.54E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	50!	S127	611.386	4816.485	3.0	91.0	0.4	0.8	373.1	2.36E+00	2.90E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	51!	V100	611.323	4816.493	14.3	94.4	0.3	11.6	373.1	2.36E+00	2.32E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	52!	GASTK	611.203	4816.633	1.0	90.3	0.1	0.01	293.0	2.36E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.35E-08
	53!	OILTK	611.359	4816.193	9.8	85.8	0.1	0.01	293.0	2.36E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.28E-06
	54!	SOLTK	611.427	4816.210	7.0	84.7	0.1	0.01	293.0	2.36E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.28E-06
	55!	BUNKTK	611.326	4816.305	5.5	89.3	0.1	0.01	293.0	2.36E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.76E-04
	56!	DIESTK	611.205	4816.630	1.0	90.4	0.1	0.01	293.0	2.36E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.06E-05
	57!	FUELTK1	611.306	4816.318	9.8	90.2	0.1	0.01	293.0	2.36E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.19E-05
	58!	FUELTK2	611.310	4816.314	9.8	90.0	0.1	0.01	293.0	2.36E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.39E-04

Industry	Stack No.	Stack Name	Coordinates - UTM - NAD83		Stack Height (m)	Base Elevation (m)	Stack Diameter (m)	Exit Velocity (m/s)	Exit Temp. (K)	Emission Rates (g/s)					
			Easting (m)	Northing (m)						SO_2	NO_x	PM	PM_{10}	$PM_{2.5}$	VOC
FORD	59!	STCK1	607.457	4816.116	35.2	116.9	0.4	5.0	500.0	1.13E-01	6.63E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	60!	STCK2	607.599	4815.988	100.0	115.2	8.1	20.1	293.0	1.13E-01	6.63E-02	1.25E+00	1.12E+00	1.67E-01	1.64E+01
	61!	STCK3	607.506	4815.877	20.7	111.9	2.1	5.8	489.0	1.13E-01	6.63E-02	9.53E-02	8.52E-02	6.01E-02	1.37E-01
	62!	STCK5	607.502	4814.976	24.5	107.0	1.1	13.3	700.0	1.13E-01	6.63E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	63!	STCK6	608.038	4814.791	20.1	102.6	0.4	5.0	500.0	1.13E-01	6.63E-02	1.89E-03	1.69E-03	1.19E-03	0.00E+00
	64!	STCK7	607.559	4815.770	20.7	111.1	1.0	14.2	293.0	1.13E-01	6.63E-02	0.00E+00	0.00E+00	0.00E+00	5.10E+00
	65!	STCK8	607.579	4815.417	22.8	111.9	0.5	15.9	293.0	1.13E-01	6.63E-02	0.00E+00	0.00E+00	0.00E+00	8.29E-01
	66!	STCK9	607.768	4815.336	24.8	112.0	1.7	14.0	505.0	1.13E-01	6.63E-02	3.68E-02	3.29E-02	2.32E-02	2.13E-02
	67!	STCK10	607.714	4815.333	24.8	113.2	1.1	12.5	293.0	0.00E+00	1.68E-01	1.15E-03	1.15E-03	3.94E-04	1.15E-01
	68!	UDB1	610.037	4817.371	9.5	99.5	0.1	0.01	293.0	0.00E+00	1.24E-01	1.15E-03	1.15E-03	3.94E-04	1.15E-01
Univ.	69!	UDB2	610.038	4817.367	9.2	99.5	0.1	0.01	293.0	0.00E+00	1.11E-01	1.15E-03	1.15E-03	3.94E-04	1.15E-01
Drums	70!	UDB3	610.036	4817.364	9.2	99.5	0.1	0.01	293.0	0.00E+00	0.00E+00	1.15E-03	1.15E-03	3.94E-04	1.15E-01
	71!	UDUH10	610.037	4817.369	7.2	99.5	0.1	0.01	293.0	0.00E+00	1.27E-03	1.15E-03	1.15E-03	3.94E-04	1.15E-01
	72!	UDUH9	610.015	4817.402	7.2	99.9	0.1	0.01	293.0	0.00E+00	1.01E-03	1.15E-03	1.15E-03	3.94E-04	1.15E-01
	73!	UDUH8	610.016	4817.403	7.2	99.9	0.1	0.01	293.0	0.00E+00	1.01E-03	1.15E-03	1.15E-03	3.94E-04	1.15E-01
	74!	UDUH7	610.031	4817.419	7.2	99.9	0.1	0.01	293.0	0.00E+00	1.01E-03	1.15E-03	1.15E-03	3.94E-04	1.15E-01

Industry	Stack No.	Stack Name	Coordinates - UTM - NAD83		Stack Height (m)	Base Elevation (m)	Stack Diameter (m)	Exit Velocity (m/s)	Exit Temp. (K)	Emission Rates (g/s)					
			Easting (m)	Northing (m)						SO_2	NO_x	PM	PM_{10}	$PM_{2.5}$	VOC
	75!	UDUH6	610.031	4817.419	7.2	99.9	0.1	0.01	293.0	0.00E+00	1.01E-03	1.15E-03	1.15E-03	3.94E-04	1.15E-01
	76!	UDUH5	610.049	4817.437	7.2	99.8	0.1	0.01	293.0	0.00E+00	1.01E-03	1.15E-03	1.15E-03	3.94E-04	1.15E-01
	77!	UDUH4	610.049	4817.438	7.0	99.8	0.1	0.01	293.0	0.00E+00	1.01E-03	1.15E-03	1.15E-03	3.94E-04	1.15E-01
	78!	UDUH3	610.066	4817.440	6.6	99.6	0.1	0.01	293.0	0.00E+00	2.53E-03	1.15E-03	1.15E-03	3.94E-04	1.15E-01
	79!	UDUH2	610.076	4817.428	6.9	99.4	0.1	0.01	293.0	0.00E+00	2.53E-03	1.15E-03	1.15E-03	3.94E-04	1.15E-01
	80!	UDUH1	610.083	4817.424	7.3	99.3	0.1	0.01	293.0	0.00E+00	2.53E-03	1.15E-03	1.15E-03	3.94E-04	1.15E-01
	81!	UDP3A	610.068	4817.425	6.1	99.5	0.1	0.01	293.0	0.00E+00	8.90E-03	1.15E-03	1.15E-03	3.94E-04	1.15E-01
	82!	UDS3A	610.036	4817.414	7.2	99.8	0.1	0.01	293.0	0.00E+00	4.90E-02	1.15E-03	1.15E-03	3.94E-04	1.15E-01
	83!	UDS5A	610.045	4817.414	8.0	99.7	0.1	0.01	293.0	0.00E+00	9.50E-03	1.15E-03	1.15E-03	3.94E-04	1.15E-01
	84!	UDS5C	610.059	4817.430	8.5	99.6	0.1	0.01	293.0	0.00E+00	1.50E-02	1.15E-03	1.15E-03	3.94E-04	1.15E-01
	85!	UDP1A	610.048	4817.403	13.3	99.6	0.1	0.01	293.0	0.00E+00	0.00E+00	1.15E-03	1.15E-03	3.94E-04	1.15E-01
	86!	UDP1B	610.053	4817.407	6.3	99.6	0.1	0.01	293.0	0.00E+00	0.00E+00	1.15E-03	1.15E-03	3.94E-04	1.15E-01
	87!	UDP1C	610.056	4817.412	13.3	99.6	0.1	0.01	293.0	0.00E+00	0.00E+00	1.15E-03	1.15E-03	3.94E-04	1.15E-01
	88!	UDP2A	610.062	4817.417	13.3	99.5	0.1	0.01	293.0	0.00E+00	0.00E+00	1.15E-03	1.15E-03	3.94E-04	1.15E-01
	89!	UDP2B	610.065	4817.414	13.3	99.5	0.1	0.01	293.0	0.00E+00	0.00E+00	1.15E-03	1.15E-03	3.94E-04	1.15E-01
	90!	UDS1A	610.040	4817.395	13.3	99.6	0.1	0.01	293.0	0.00E+00	0.00E+00	1.15E-03	1.15E-03	3.94E-04	1.15E-01
	91!	UDS1B	610.034	4817.382	13.3	99.6	0.1	0.01	293.0	0.00E+00	0.00E+00	1.15E-03	1.15E-03	3.94E-04	1.15E-01
	92!	UDS2A	610.013	4817.392	11.6	99.8	0.1	0.01	293.0	0.00E+00	0.00E+00	1.15E-03	1.15E-03	3.94E-04	1.15E-01
	93!	UDS2B	610.018	4817.397	11.3	99.8	0.1	0.01	293.0	0.00E+00	0.00E+00	1.15E-03	1.15E-03	3.94E-04	1.15E-01

Industry	Stack No.	Stack Name	Coordinates - UTM - NAD83		Stack Height (m)	Base Elevation (m)	Stack Diameter (m)	Exit Velocity (m/s)	Exit Temp. (K)	Emission Rates (g/s)					
			Easting (m)	Northing (m)						SO_2	NO_x	PM	PM_{10}	$PM_{2.5}$	VOC
	94!	UDS2C	610.023	4817.402	11.3	99.8	0.1	0.01	293.0	0.00E+00	0.00E+00	1.15E-03	1.15E-03	3.94E-04	1.15E-01
	95!	UDS4A	610.085	4817.418	12.7	99.3	0.6	8.1	300.0	0.00E+00	0.00E+00	1.15E-03	1.15E-03	3.94E-04	1.15E-01
	96!	UDS5B	610.048	4817.417	8.4	99.7	0.1	0.01	293.0	0.00E+00	0.00E+00	1.15E-03	1.15E-03	3.94E-04	1.15E-01
	97!	UDS6A	610.057	4817.407	13.3	99.6	0.1	0.01	293.0	0.00E+00	0.00E+00	1.15E-03	1.15E-03	3.94E-04	1.15E-01
	98!	UDS6B	610.054	4817.402	13.3	99.6	0.1	0.01	293.0	0.00E+00	0.00E+00	1.15E-03	1.15E-03	3.94E-04	1.15E-01
	99!	UDS7A	610.028	4817.381	13.3	99.6	0.1	0.01	293.0	0.00E+00	0.00E+00	1.15E-03	1.15E-03	3.94E-04	1.15E-01
	100!	UDSTCK1	610.001	4817.400	6.7	100.0	0.1	0.01	293.0	0.00E+00	0.00E+00	1.15E-03	1.15E-03	3.94E-04	1.15E-01
ORION	101!	STCK1OR	611.094	4815.981	11.0	85.5	0.9	10.4	296.0	0.00E+00	0.00E+00	3.63E-03	1.79E-03	6.84E-04	2.10E-01
	102!	STCK2OR	611.098	4815.978	11.0	85.5	0.9	10.4	296.0	0.00E+00	0.00E+00	3.63E-03	1.79E-03	6.84E-04	2.10E-01
	103!	STCK3OR	611.104	4815.997	11.1	85.3	0.2	11.6	296.0	0.00E+00	0.00E+00	3.63E-03	1.79E-03	6.84E-04	2.44E-02
	104!	STCK4OR	611.105	4815.998	11.1	85.3	1.1	11.3	296.0	0.00E+00	0.00E+00	3.63E-03	1.79E-03	6.84E-04	2.38E-01
	105!	STCK5OR	611.111	4816.004	11.1	85.2	1.1	11.3	296.0	0.00E+00	0.00E+00	3.63E-03	1.79E-03	6.84E-04	2.38E-01
	106!	STCK8OR	611.114	4815.988	11.1	85.3	1.1	11.3	296.0	0.00E+00	0.00E+00	3.63E-03	1.79E-03	6.84E-04	2.38E-01
	107!	STCK9OR	611.121	4815.995	11.1	85.2	1.1	11.3	296.0	0.00E+00	0.00E+00	3.63E-03	1.79E-03	6.84E-04	2.38E-01
	108!	STCK11OR	611.136	4816.011	11.1	85.0	1.1	11.3	296.0	0.00E+00	0.00E+00	3.63E-03	1.79E-03	6.84E-04	2.38E-01
	109!	STCK12OR	611.142	4816.017	11.1	84.9	1.1	11.3	296.0	0.00E+00	0.00E+00	3.63E-03	1.79E-03	6.84E-04	2.38E-01
	110!	STCK7OR	611.113	4815.987	11.1	85.3	0.2	11.6	296.0	0.00E+00	0.00E+00	3.63E-03	1.79E-03	6.84E-04	2.44E-02
	111!	STCK10OR	611.135	4816.009	11.1	85.0	0.2	11.6	296.0	0.00E+00	0.00E+00	3.63E-03	1.79E-03	6.84E-04	2.44E-02
	112!	STCK6OR	611.127	4816.016	11.1	85.1	1.1	13.1	296.0	0.00E+00	0.00E+00	3.63E-03	1.79E-03	6.84E-04	1.59E-01

Industry	Stack No.	Stack Name	Coordinates - UTM - NAD83		Stack Height (m)	Base Elevation (m)	Stack Diameter (m)	Exit Velocity (m/s)	Exit Temp. (K)	Emission Rates (g/s)					
			Easting (m)	Northing (m)						SO_2	NO_x	PM	PM_{10}	$PM_{2.5}$	VOC
	113!	STCK17 OR	611.077	4815.973	5.8	85.7	0.5	3.4	296.0	0.00E+00	0.00E+00	3.63E-03	1.79E-03	6.84E-04	4.48E-03
	114!	STCK18 OR	611.192	4815.868	8.5	84.8	0.2	35.0	421.0	0.00E+00	0.00E+00	3.63E-03	1.79E-03	6.84E-04	1.58E-03
	115!	STCK19 OR	611.106	4815.927	2.7	85.7	0.2	17.4	296.0	0.00E+00	0.00E+00	3.63E-03	1.79E-03	6.84E-04	0.00E+00
	116!	STCK13 OR	611.136	4815.947	11.1	85.2	0.9	10.3	296.0	0.00E+00	0.00E+00	3.63E-03	1.79E-03	6.84E-04	5.75E-02
	117!	STCK14 OR	611.141	4815.953	11.1	85.1	0.9	10.3	296.0	0.00E+00	0.00E+00	3.63E-03	1.79E-03	6.84E-04	5.75E-02
	118!	STCK15 OR	611.178	4815.997	11.1	84.7	0.9	10.3	296.0	0.00E+00	0.00E+00	3.63E-03	1.79E-03	6.84E-04	5.75E-02
	119!	STCK16 OR	611.182	4816.000	11.1	84.6	0.9	10.3	296.0	0.00E+00	0.00E+00	3.63E-03	1.79E-03	6.84E-04	5.75E-02
PPG	120!	EC319	610.531	4817.452	9.6	98.2	0.1	0.1	298.1	1.64E-05	1.14E-03	5.19E-04	2.60E-04	1.30E-04	0.00E+00
	121!	MFG077	610.487	4817.473	2.5	98.0	0.2	2.7	298.0	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	122!	MFG082	610.462	4817.472	6.5	98.1	0.5	3.2	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	123!	MFG208	610.469	4817.497	12.3	97.9	0.1	1.5	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	124!	MFG209	610.463	4817.498	12.3	98.0	0.1	1.5	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	125!	MFG210	610.461	4817.497	12.3	98.0	0.1	1.5	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	126!	MFG211	610.465	4817.492	12.3	98.0	0.1	1.5	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	127!	MFG214	610.458	4817.474	12.3	98.1	0.9	0.0	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00

Industry	Stack No.	Stack Name	Coordinates - UTM - NAD83		Stack Height (m)	Base Elevation (m)	Stack Diameter (m)	Exit Velocity (m/s)	Exit Temp. (K)	Emission Rates (g/s)					
			Easting (m)	Northing (m)						SO_2	NO_x	PM	PM_{10}	$PM_{2.5}$	VOC
	128!	MFG217	610.437	4817.483	12.3	98.2	0.1	0.5	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	129!	MFG218	610.443	4817.489	12.3	98.2	0.1	0.5	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	130!	MFG219	610.445	4817.482	12.3	98.2	0.1	0.5	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	131!	MFG220	610.443	4817.478	12.3	98.2	0.1	0.5	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	132!	MFG325	610.470	4817.496	6.5	98.0	0.5	3.2	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	133!	MFG327	610.480	4817.498	6.9	97.9	0.5	5.9	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	134!	MFG329	610.480	4817.500	10.4	97.9	0.7	6.7	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	135!	MFG322	610.432	4817.501	10.7	98.2	2.1	2.7	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	136!	MFG323	610.435	4817.498	10.7	98.2	2.1	2.6	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	137!	MFG340	610.421	4817.473	9.0	98.3	17.3	0.0	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	138!	MFG341	610.425	4817.465	12.3	98.3	0.1	1.8	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	139!	MFG342	610.425	4817.469	9.0	98.3	17.3	0.0	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	140!	EB96	610.327	4817.557	12.0	99.0	0.6	5.4	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00

Industry	Stack No.	Stack Name	Coordinates - UTM - NAD83		Stack Height (m)	Base Elevation (m)	Stack Diameter (m)	Exit Velocity (m/s)	Exit Temp. (K)	Emission Rates (g/s)					
			Easting (m)	Northing (m)						SO_2	NO_x	PM	PM_{10}	$PM_{2.5}$	VOC
	141!	EB104	610.368	4817.585	2.6	99.0	0.1	2.0	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	142!	EB169	610.399	4817.532	10.1	98.7	16.6	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	143!	EB170	610.394	4817.538	10.1	98.7	17.0	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	144!	EB171	610.389	4817.543	10.1	98.8	17.0	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	145!	EB172	610.383	4817.547	10.1	98.8	17.0	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	146!	EB173	610.373	4817.558	10.1	98.9	17.0	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	147!	EB174	610.368	4817.563	10.1	98.9	17.0	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	148!	EB175	610.363	4817.568	10.1	98.9	18.0	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	149!	EB176	610.357	4817.574	10.1	99.0	15.5	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	150!	EB177	610.352	4817.579	10.1	99.0	18.0	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	151!	EB178	610.369	4817.574	10.1	99.0	13.0	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	152!	EB179	610.373	4817.547	14.3	98.9	31.0	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	153!	EB180	610.398	4817.533	14.8	98.7	29.0	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00

Industry	Stack No.	Stack Name	Coordinates - UTM - NAD83		Stack Height (m)	Base Elevation (m)	Stack Diameter (m)	Exit Velocity (m/s)	Exit Temp. (K)	Emission Rates (g/s)					
			Easting (m)	Northing (m)						SO_2	NO_x	PM	PM_{10}	$PM_{2.5}$	VOC
	154!	EB181	610.378	4817.553	14.8	98.9	31.0	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	155!	EB182	610.377	4817.568	14.3	98.9	31.0	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	156!	EB183	610.365	4817.580	14.3	99.0	31.7	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	157!	EB184	610.346	4817.575	17.6	99.0	31.7	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	158!	EB185	610.344	4817.576	13.0	99.0	16.4	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	159!	EB352	610.451	4817.554	10.2	98.7	0.1	1.8	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	160!	OEM186	610.464	4817.534	12.9	98.4	14.5	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	161!	OEM187	610.465	4817.535	12.9	98.5	14.5	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	3.64E+00
	162!	OEM188	610.468	4817.538	12.9	98.5	14.5	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	3.64E+00
	163!	OEM189	610.462	4817.536	12.9	98.5	14.5	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	3.64E+00
	164!	OEM190	610.465	4817.538	12.9	98.5	14.5	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	3.64E+00
	165!	OEM152	610.420	4817.533	11.4	98.6	6.7	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	166!	OEM153	610.420	4817.532	12.1	98.6	17.8	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00

Industry	Stack No.	Stack Name	Coordinates - UTM - NAD83		Stack Height (m)	Base Elevation (m)	Stack Diameter (m)	Exit Velocity (m/s)	Exit Temp. (K)	Emission Rates (g/s)					
			Easting (m)	Northing (m)						SO_2	NO_x	PM	PM_{10}	$PM_{2.5}$	VOC
	167!	OEM154	610.419	4817.531	11.4	98.6	6.7	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	168!	OEM155	610.418	4817.530	11.4	98.6	6.7	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	169!	OEM157	610.416	4817.529	11.4	98.6	6.7	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	170!	OEM158	610.414	4817.526	11.4	98.6	6.7	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	171!	OEM159	610.414	4817.526	11.4	98.6	6.7	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	172!	OEM160	610.412	4817.524	11.4	98.6	6.7	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	173!	OEM166	610.415	4817.527	12.1	98.6	17.7	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	174!	OEM115	610.424	4817.544	11.7	98.7	12.3	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	175!	OEM141	610.425	4817.545	11.7	98.7	12.3	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	3.64E+00
	176!	OEM142	610.426	4817.546	11.7	98.7	12.3	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	3.64E+00
	177!	OEM143	610.427	4817.547	11.7	98.7	12.3	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	3.64E+00
	178!	OEM144	610.435	4817.544	11.7	98.7	12.3	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	179!	OEM145	610.433	4817.542	11.7	98.6	12.3	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00

Industry	Stack No.	Stack Name	Coordinates - UTM - NAD83		Stack Height (m)	Base Elevation (m)	Stack Diameter (m)	Exit Velocity (m/s)	Exit Temp. (K)	Emission Rates (g/s)					
			Easting (m)	Northing (m)						SO_2	NO_x	PM	PM_{10}	$PM_{2.5}$	VOC
	180!	OEM146	610.430	4817.539	11.7	98.6	12.3	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	181!	OEM147	610.429	4817.537	11.7	98.6	12.3	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	3.64E+00
	182!	OEM150	610.423	4817.536	11.4	98.6	3.0	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	183!	OEM151	610.417	4817.538	11.4	98.7	3.7	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	184!	OEM148	610.424	4817.535	11.4	98.6	3.3	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	185!	OEM123	610.433	4817.551	19.3	98.7	14.5	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	3.64E+00
	186!	OEM124	610.434	4817.553	19.3	98.8	14.5	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	3.64E+00
	187!	OEM125	610.435	4817.554	19.3	98.8	14.5	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	3.64E+00
	188!	OEM126	610.437	4817.555	19.3	98.8	14.5	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	3.64E+00
	189!	OEM127	610.427	4817.559	19.3	98.8	14.5	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	3.64E+00
	190!	OEM128	610.428	4817.561	19.3	98.8	14.5	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	191!	OEM129	610.430	4817.563	19.3	98.9	14.5	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	192!	OEM133	610.443	4817.561	19.3	98.8	17.3	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00

Industry	Stack No.	Stack Name	Coordinates - UTM - NAD83		Stack Height (m)	Base Elevation (m)	Stack Diameter (m)	Exit Velocity (m/s)	Exit Temp. (K)	Emission Rates (g/s)					
			Easting (m)	Northing (m)						SO_2	NO_x	PM	PM_{10}	$PM_{2.5}$	VOC
	193!	OEM134	610.445	4817.562	19.3	98.8	24.5	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	194!	OEM137	610.447	4817.556	20.2	98.8	52.0	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	195!	OEM138	610.442	4817.551	20.2	98.7	52.0	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
	196!	OEM191	610.451	4817.549	12.9	98.7	6.3	0.01	298.1	1.64E-05	1.14E-03	8.96E-04	2.60E-04	1.30E-04	0.00E+00
Stack	197!	STCK1SP	610.395	4817.389	22.7	98.4	0.6	16.2	291.9	0.00E+00	1.87E-01	1.88E-01	9.34E-02	4.66E-02	7.38E-02
Pole	198!	STCK2SP	610.398	4817.379	22.7	98.4	0.6	9.6	291.9	0.00E+00	1.87E-01	1.88E-01	9.34E-02	4.66E-02	7.38E-02
	199!	STCK3SP	610.388	4817.370	22.7	98.4	0.7	12.5	291.9	0.00E+00	1.87E-01	1.88E-01	9.34E-02	4.66E-02	7.38E-02
	200!	STCK4SP	610.379	4817.361	22.7	98.3	0.6	9.6	291.9	0.00E+00	1.87E-01	1.88E-01	9.34E-02	4.66E-02	7.38E-02
	201!	STCK5SP	610.369	4817.354	22.7	98.3	0.6	17.8	291.9	0.00E+00	1.87E-01	1.88E-01	9.34E-02	4.66E-02	7.38E-02
Westroc	202!	WESTROC	611.722	4816.487	20.0	80.5	0.5	15.0	291.9	0.00E+00	0.00E+00	2.25E-02	2.25E-02	2.20E-02	7.29E-01
Royal Ready Mix	203!	ROYAL	610.300	4817.380	20.0	98.4	0.6	16.2	291.9	0.00E+00	0.00E+00	0.00E+00	5.00E-02	2.66E-02	6.34E-03

Notes:

Emissions from the above mentioned industries are modelled as point sources in Clarkson Airshed Study Area, except those that were not reported which are captured under the area sources (postal codes).

Ashland emissions were modelled as volume sources and not as point sources, for this reason it is not included in Appendix A.

Royal Ready Mix was modelled as a unit emission rate and pro-rated with NPRI's 2004 emissions.